With Compliments of

M McDonald

U. S. Commissioner of Fish and Fisheries.

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UNITED STATES FISH COMMISSION.

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GOVERNMENT PRINTING OFFICE.
1891.

Joint Resolution authorizing the Public Printer to print Reports of the United States Fish Commissioner upon new Discoveries in regard to Fish-culture.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Public Printer be, and he hereby is, instructed to print and stereotype, from time to time, any matter furnished him by the United States Commissioner of Fish and Fisheries, relative to new observations, discoveries, and applications connected with fish-culture and the fisheries, to be capable of being distributed in parts, and the whole to form an annual volume or bulletin not exceeding five hundred pages. The extra edition of said work shall consist of five thousand copies, of which two thousaud five hundred shall be for the use of the House of Representatives, one thousand for the use of the Senate, and one thousand five hundred for the use of the Commissioner of Fish and Fisheries.

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ADVERTISEMENT.

UNITED STATES COMMISSION OF FISH AND FISHERIES,
Washington, D. C.

Congress by joint resolution of February 14, 1881, authorized the printing of an annual bulletin for the publication of new observations, discoveries, and applications relating to fish-culture and the fisheries. Prior to 1888 the numbers of the bulletin were composed chiefly of short articles, extracts from the official correspondence, and translations of foreign papers. From that time, however, the increased operations of the Fish Commission have made it possible to apply the publication almost exclusively to the results of the Commission's work, and the present volume will be found to contain much original material of great importance to fish-culture and the fishery interests. The unbound edition of the volume has been issued in the form of completed papers, and the distribution has consequently been much more satisfactory than the former method of mailing by signatures.

The present bulletin is the ninth of the series.

MARSHALL McDONALD,
Commissioner.

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1.—REPORT OF EXPLORATIONS IN COLORADO AND UTAH DURING THE SUMMER OF 1889, WITH AN ACCOUNT OF THE FISHES FOUND IN EACH OF THE RIVER BASINS EXAMINED.

BY DAVID STARR JORDAN.

[Plates I to V.]

INTRODUCTION.

Under the instruction of the U. S. Commissioner of Fish and Fisheries, Hon. Marshall McDonald, the writer undertook to make a series of examinations of the different streams of Colorado and Utah. This examination had two general purposes: First, to ascertain the general character of the streams of the Rocky Mountains and the Great Basin, their present stock of food-fishes, and their suitability for the introduction of species not now found there; second, to catalogue the fishes native to each stream, whether food-fishes or not, in order to increase our knowledge of the geographical distribution of each species and to throw further light on the laws which govern geographical distribution.

In the present paper is given an account of each stream, a list of the fishes found in it, and such notes, geographical or economic, as add to our knowledge of it.

In the work of the summer the writer had the very efficient help of his students, Prof. Barton W. Evermann of the Indiana State Normal School at Terre Haute, Mr. Bert Fesler of Topeka, Kans., and Mr. Bradley M. Davis of Chicago, Ill. The prosecution of the work was also materially aided by the help given by Mr. Richard Rathbun, assistant in charge of the work of scientific inquiry in the U. S. Fish Commission. We were also much indebted to several citizens of the regions visited for the interest they showed in our work and the help rendered by them. Of these we may mention especially Mr. George R. Fisher of Leadville, Hon. Gordon Land, fish commissioner of Colorado, Mr. Peter Madsen of Provo, Utah, and Mr. J. F. Brown of Blake City, Utah. Efficient help was also rendered by Col. John Gay, assistant to the U. S. Fish Commission, then in charge of the erection of the fish hatchery at Evergreen Lake, near Leadville.

The streams examined may be grouped as follows:

A.—Platte River:

- South Platte River, at Hartsel's Hot Springs, in the South Park.
- South Platte River, at Denver.
- Bear Creek, at Morrison.
- Boulder Creek, above Boulder.

B.—Arkansas River:

Arkansas River, near Leadville, Colo.
Lake Fork, near Leadville.
Evergreen Lakes, near Leadville.
Twin Lakes, at Interlaken, Colo.
Lake Creek, near Granite, Colo.
Arkansas River, at Cañon City, Colo.
Grape Creek, at Cañon City, Colo.
Arkansas River, at Good Night Ranch, near Pueblo, Colo.
Font-qui-Bouille Creek, at Manitou Springs.
Ruxton Creek, at Manitou Springs.
Fountain Creek, at Pueblo.
Arkansas River, at Coolidge, Kans.
Arkansas River, at Wichita, Kans. (Collections of Mr. Sherman Davis.)

C.—Rio Grande:

Rio Grande, at Del Norte, Colo.
Rio Grande, at Alamosa, Colo.
Rio Conejos, at McIntire's Ranch, below Alamosa.
Rio Chama, at Chama, N. Mex.
San Luis Lakes, near Alamosa.

D.—Colorado River:

Grand River, Glenwood Springs, Colo.
Sweetwater Lake, Eagle County, Colo.
Trapper's Lake, Garfield County, Colo.
Eagle River, at Gypsum, Colo.
Roaring Fork, above Glenwood Springs.
Cañon Creek, below Glenwood Springs.
Gunnison River, at Gunnison, Colo.
Tomichi Creek, at Gunnison, Colo.
Cimarron Creek, at Cimarron, Colo.
Gunnison River, at Delta, Colo.
Uncompahgre River, at Ouray, Colo.
Uncompahgre River, at Delta, Colo.
Green River, at Blake City, Utah.
Price River, at Castle Gate, Utah.
Rio de las Animas Perdidas, at Durango, Colo.
Mineral Creek, at Silverton, Colo.
Leitner's Creek, at Durango, Colo.
Rio Florida, near Durango, Colo.

E.—Salt Lake Basin:

Utah Lake, at Provo, Utah.
Provo River, at Provo, Utah.
Jordan River, above Salt Lake City.
Great Salt Lake.

F.—Sevier Lake Basin:

Sevier River, near Juab, Utah.
Chicken Lake, near Juab, Utah.

The following is, in brief, the itinerary of the summer's work:

July 16.—Left Bloomington in company with Prof. B. W. Evermann.
July 17.—Joined at Kansas City by Mr. B. M. Davis.
July 18.—At Coolidge, Kans.
July 19.—Arrived at Pueblo, Colo.
July 20.—Drove to Good Night Ranch; seined the Arkansas River and Fountain Creek.

July 22.—At Cañon City; seined Arkansas River and Grape Creek.
July 23.—At Granite; seined Lake Creek.
July 24.—At Leadville; seined Arkansas River.
July 25, 26.—Went to Twin Lakes with Col. John Gay and Mr. George R. Fisher; met Mr. Gordon Land; obtained specimens of trout of two varieties.
July 27.—At Glenwood Springs; seined Roaring Fork and Grand River.
July 28, 29.—At Gunnison; joined by Mr. Bert Fesler; Evermann and Davis remain a day at Gypsum.
July 30.—At Gunnison; seined Gunnison River and Tomichi Creek.
July 31.—At Cimarron; seined Cimarron Creek.
August 1, 2.—At Delta; seined Gunnison and Uncompahgre Rivers.
August 4, 5.—At Provo; seined Provo River and, assisted by Peter Madsen and his sons, drew a long net in Utah Lake.
August 6, 7.—Salt Lake City; seined Jordan River.
August 9, 10.—At Juab; seined Sevier River and Chicken Lake.
August 11, 12.—At Green River (Blake City), Utah; seined the river, assisted by Mr. J. F. Brown.
August 13, 14.—At Ouray; examined Uncompahgre River.
August 15, 16.—At Durango; seined Rio de las Animas Perdidas and Rio Florida.
August 17–19.—At Alamosa, Colo.; Evermann and Fesler visit Del Norte, Colo.; seined Rio Grande, Rio Conejos, and San Luis Lakes.
August 20, 21.—At Manitou Springs.
August 22.—At Hartsel's Hot Springs; seined the South Platte.
August 23.—At Denver; seined the South Platte.
August 24.—At Boulder; seined Boulder Creek; Fesler and Davis visit Morrison, seining Bear Creek.
August 25.—Left Colorado, reaching Bloomington, Ind., August 27.

COLORADO.

The State of Colorado is for the most part an elevated and arid region, traversed by ranges of lofty mountains extending north and south, one of them being the main divide of the continent, which is nowhere crossed by streams.

In the eastern part of the State the mountains cease almost abruptly, and give place to the sage-plains, an elevated and nearly level region which slopes gradually eastward through Kansas and Nebraska to the Missouri River. This region has in Colorado little rain-fall. Its vegetation is scanty, except along the streams, where the soil may be made very fertile by irrigation. In the central part of the State elevated and arid valleys rendered fertile by irrigation lie between the mountain chains. On the north slopes of mountains, especially northward, are considerable pine forests, while above the timber line are level grassy areas, mountain meadows, well watered and with a profusion of wild flowers. The mountain chains also sometimes inclose large flat green areas, many of them former lake beds, which have become filled with sediment and the débris of vegetation. These are known as parks, and in these the clear mountain streams pursue courses with interminable meanderings and with but slight current.

In the western part of Colorado the great folds of the granite mountains give place largely to horizontal strata. Here erosion of water on a grand scale has filled this region with gorges, the intervening rocks being left as mesas and buttes. In one case, the Grand Mesa stands at a height of nearly a mile above the Gunnison River at Delta, the top of the mesa being reached by some seven or eight successive stairs, each representing a separate plane of erosion.

In the northwestern part of Colorado are many clear lakes of glacial origin, but in the rest of the State the lakes are comparatively few.

Most of the streams of Colorado rise in springs in or above the mountain meadows, many of them having their origin in banks of snow, which the clear weather of summer is not sufficient wholly to melt.

These streams are clear and very cold. In their descent from the snow-banks they are brawling and turbulent, often so much so as to be unfitted for fish life. In their course through the mountain meadows (very similar to the "Alp" pastures of Switzerland) the streams are usually of gentle current, with many windings and with occasional deep holes beloved of trout. Lower down most of them pass to the valleys through deep cañons, some of them very deep and with many rapids. Vertical falls are, however, very rare in Colorado, and most of these cañons form no obstacle to trout. Below the cañons, the stream, still clear and cold, enters the valley, where the flat bottom is usually covered deep with sediment which the streams bring down.

Here the water grows warmer, the fine silt renders it more or less turbid, and at last it becomes unfit for trout and at the same time suitable for the suckers and chubs. In the winter and spring the water is cold and clear for some distance down the valleys. In these seasons the trout extend their range to a corresponding degree. In the summer and fall they are more or less confined to the mountains or the cañons. Often the stream after entering the valley cuts its way through a moraine deposit. In that case its course is filled with boulders, and its waters are sometimes as brawling in a boulder-strewn valley as in the mountains.

In some cases placer-mining and stamp-mills have filled the waters of otherwise clear streams with yellow or red clay, rendering them almost uninhabitable for trout. Parts of the upper Arkansas and Grand Rivers have been almost ruined as trout streams by mining operations. In a few streams the presence of iron springs seems to exclude all fishes.

After reaching the base of the mountains the streams flow with little current over the ill-defined beds across the plains. They tear up the fine soil and shift it from place to place. Occasional rains swell the dry beds of "Sand-Arroyos;" the stream becomes more and more charged with clayey sediment, and in time not one of these rivers would be recognized as the crystal-clear stream which came down the mountains. The Platte spreads out broad and shallow over the plain, and its course is full of quicksands. Its banks are rarely well defined. The Arkansas resembles the Platte, being even more muddy, however, and the Rio Grande is similar to it. The Colorado carries the peculiar erosion of the mesas to a still greater extent as it goes southward. The stream is large and swift, with treacherous currents and shifting bottom. As no rain-fall or frosts wear away its banks, it sinks deeper and deeper below the surface, until it forms the deepest gorge in the world, with banks which are vertical or like stair-cases.

In the progress of settlement of the valleys of Colorado the streams have become more and more largely used for irrigation. Below the mouth of the cañons dam after dam and ditch after ditch turn off the water. In summer the beds of even large rivers (as the Rio Grande) are left wholly dry, all the water being turned into these ditches. Much of this water is consumed by the arid land and its vegetation; the rest seeps back, turbid and yellow, into the bed of the stream, to be again intercepted as soon as enough has accumulated to be worth taking. In some valleys, as in the San Luis, in the dry season there is scarcely a drop of water in the river-bed that has

not from one to ten times flowed over some field, while the beds of many considerable streams (Rio la Jara, Rio Alamosa, etc.) are filled with dry clay and dust.

Great numbers of trout, in many cases thousands of them, pass into these irrigating ditches and are left to perish in the fields. The destruction of trout by this agency is far greater than that due to all others combined, and it is going on in almost every irrigating ditch in Colorado.

It is not easy to suggest a remedy for it. The valleys in question would be worthless for agriculture were it not for irrigation, and the economic value of the trout is but a trifle as compared with the value of the water privileges. It is apparently impossible to shut out the trout from the ditches by any system of screens. These screens soon become clogged by silt, dead leaves, and sage brush, and thus will not admit the passage of the water.

Perhaps most of the trout are lost by entering the ditches in the fall, when running down stream with the cooling of the water. It has been suggested that a law could compel the closing of the ditches after the harvest, allowing the streams to flow freely until March or April. In the fall the water is worth most to the fishes and least to the farmers. I am unable to say whether this plan will prove practicable or effective. This is certain, that if the present conditions go on the trout in the lower courses of all the streams will be exterminated, and there will be trout only in the mountain lakes and in the mountain meadows, to which agriculture can not extend.

INDIGENIOUS FISHES.

The fishes of Colorado are very few in number, notwithstanding the fact that four distinct faunal basins are within the limits of the State.

The trout, *Salmo mykiss* Walbaum, and its varieties are found in all the mountain lakes and streams, down to a point where the summer temperature reaches 60° to 65°, when they gradually disappear. In clear streams and streams with bottoms of gravel they extend much farther than in turbid streams or those with clay bottoms.

The mountain minnows, *Rhinichthys dulcis*, on the eastern slope and in the Rio Grande, and *Agosia yarrowi*, in the Colorado basin, accompany the trout in the mountain meadows, not, however, ascending so near to the sources of the stream. On the other hand, they extend their range farther down than the trout, and exist in millions in the upper part of some of the valleys. They seem to be harmless little fishes, and they are eaten by the trout.

The blob or Miller's Thumb (*Cottus bairdi punctulatus*) is equally fond of cold and clear waters. In the Colorado basin it is very abundant, but in the other regions it is scarce, if present, and we did not find it. It is very destructive to the eggs of trout.

The suckers of various species extend up the rivers more or less to the point where the trout disappear. Generally speaking, the suckers of the different basins are unlike. We found *Catostomus griseus* and *Catostomus teres* in the Platte, the former ascending the streams much higher than the latter. In the Arkansas, *Catostomus teres;* in the Rio Grande, *Pantosteus plebeius;* in the Colorado, *Pantosteus delphinus*, *Catostomus latipinnis*, and *Xyrauchen cypho.* The species of *Catostomus* and *Xyrauchen* reach a considerable size, and are food-fishes of poor quality. All are destructive to the eggs of the trout.

More destructive, however, are the chubs (*Leuciscus*). Of these, none ascend to the mountains in the Arkansas or the Platte. But, in the Rio Grande, one species, *Leuciscus pulcher*, exists in abundance, while in the Colorado, the Round-Tail (*Gila robusta*) is equally common. Another chub-like fish in the Colorado, *Ptychocheilus lucius*, reaches a great size, the largest of all the *Cyprinidæ*, and in default of better fish, assumes economic importance.

Other minnows ascend the Arkansas and Platte, though only to the foot of the mountains. Most of these are of species common in the Mississippi Valley. The bulk of the rich fauna of the Mississippi is however excluded from Colorado, because the species can not ascend the turbid waters of the lower Arkansas or Platte.

The darters, sunfishes, and catfishes can hardly be said to belong to Colorado, as nearly all the species are shut out by the unfit character of the lower streams. These were seen by us only about Denver and Pueblo. In a similar way most of the Texan fishes are excluded from the Rio Grande.

INTRODUCED FISHES.

The Eastern brook trout (*Salvelinus fontinalis*) has been introduced into numerous streams (Bear Creek, Twin Lakes, Echo Lake in Egeria Park, Ruxton Creek, Tomichi Creek, etc.). It does well everywhere, and is said to grow more rapidly than the native trout, but this statement is denied by some partisans of the latter fish.

The rainbow trout of California (*Salmo irideus*) has been sparingly introduced, and is reported to do well. One specimen was obtained by us in Twin Lakes.

The land-locked salmon of Maine (*Salmo salar sebago*) has been introduced into Twin Lakes, where specimens are occasionally taken.

A number of carp-ponds also exist in the State.

As an addition to the above list, I would strongly recommend the introduction of the larger catfishes, especially *Leptops olivaris*, *Ictalurus punctatus*, and *Ameiurus nebulosus*, into the tributaries of the lower Colorado, as the Green River and the San Juan. Food is abundant, and every condition seems to be favorable for them, while the whole great basin of the Colorado contains, excepting the trout, no fish of even second-rate character as food for man.

A.—THE PLATTE BASIN.

The South Platte rises in the elevated plateau known as the South Park. Through the park it flows in an undulating course over grassy fields, finally breaking through the mountains to the sage plains above Denver. It receives many tributaries from the mountains, and the waters of numerous sandy runs, dry in summer, pour in from the plains. Its water, both above and below Denver, is largely used for irrigation. Thus it becomes a shallow, muddy stream, with sandy bottom and very low banks. In the northeastern part of Colorado it meets its fellow, the North Platte, a stream of similar character, rising in the North Park. The Platte, now a broad, very shallow stream, full of sandbars and quicksands, flows eastward across Nebraska to the Missouri. The fishes of the Platte, as far up as Denver, are mostly the ordinary species of the upper Missouri region. The trout do not descend below the level of the parks, and are scarce even in the South Park itself, being chiefly confined to the mountain gorges above it.

Collections were made at the following points:

1. *Hartsel's Hot Springs*, in the South Park, about 15 miles below the foot of the Park Range.—The South Platte here flows through grassy meadows, a fairly clear stream, a little soiled by the seepage from the irrigating ditches. Water rather cold, about 65°. In summer the stream is about 10 feet broad, 2 to 3 feet deep, with many deep holes in its windings. It is literally full of suckers (*Catostomus griseus*). *Rhinichthys dulcis* is also abundant, but no other species were seen. Trout are found in the mountains above and frequently descend to the level of the park where they are carried out over the fields by the irrigating ditches. It is said that a washtub full of young trout were picked up from the ditch at Hartsel's last fall. Species from this locality are marked H.

2. *Denver*.—Collections were made in the Platte at the bridge just below the mouth of Bear Creek, 6 miles above Denver. The river is there 1 to 6 rods wide and 2 to 4 feet deep. Temperature about 72°. The water is grayish or brownish, nearly clear, with a bottom of gravel and sand. Fishes are very abundant, nine species being taken. These are marked D in the following list.

At its mouth, Bear Creek is clear, but very warm, the water being all seepage from irrigating ditches. It contains the same species as the river.

3. *Bear Creek*, above Morrison.—Seined at a point 10 miles up the cañon from Morrison, near Hines's. The stream is here about 20 feet wide and 3 feet deep. The water is clear and swift, with a bottom of gravel and boulders. Temperature about 67°. Trout are here abundant, both the native and the Eastern brook trout, which has been introduced. The suckers and minnows are the same as at Hartsel's. The species taken at Morrison are marked M.

4. *Middle Boulder Creek*, above Boulder.—Examined at various places in Boulder cañon to a point 12 miles above Boulder. A swift, clear, very cold (54°) mountain stream, full of rapids and deep pools. The bottom is everywhere made up of boulders, so that a net could not be used. It is said that trout are abundant in the upper part of the cañon, and that the fishing is especially good in the mountain pastures above the top of the cañon. The only fishes taken were young suckers, marked B in the following list:

FISHES OF THE PLATTE BASIN.

1. Catostomus teres sucklii (Girard). D.

Abundant at Denver.

2. Catostomus griseus (Girard). D., H., B., M.

Abundant everywhere, but especially so in the upper courses of the streams. D. 10. Scales 102. About six rows of tubercles on upper lip. Dorsal not nearer base of caudal than snout, except in the larger specimens. Lower lip with a slight cartilaginous sheath. Body long and low, dusky above, paler below. As already noticed in a paper on the fishes of the Yellowstone Park, this species seems to be the same as *Acomus lactarius* Girard and *Catostomus retropinnis* Jordan. It appears to differ from *C. catostomus* (Forster) in the greater number of rows of tubercles on the upper lip and in the greater inequalities of the scales on the body. But our specimens of *C. catostomus* are not numerous enough to test fully the value of these characters, and further study may show that this form intergrades with the other.

3. **Hybognathus nuchalis** Agassiz (? var. **placita** Girard). D.

Rather rare about Denver. The specimens are all somewhat stout in form, the nose a little blunter than usual and rather less projecting beyond the mouth. Color very dark, the scales dark edged, and a dark lateral shade. Suborbitals very narrow. Eye 4 in head.

These specimens may belong to the form called *placita*, but the distinctions of varieties and species in this group are very unsatisfactory.

4. **Notropis scylla** (Cope). D.

A few specimens from Denver, similar to others from Pueblo.

5. **Notropis gilberti** Jordan and Meek. D.

Very abundant at Denver. These specimens agree closely with the original types from the Des Moines River at Ottumwa, indicating that the species has a wide distribution over the western plains. The species has the lips somewhat thickened, and there is a little fleshy projection at the corner of the mouth, not, however, amounting to a barbel. A little dusky shade on each side of the dorsal fin seems to be characteristic. *Photogenis piptolepis* Cope may be this species, but the description is not sufficiently full to permit identification.

6. **Notropis megalops** (Rafinesque). D.

Not common; apparently typical, scales before dorsal 23.

7. **Notropis lutrensis** (Baird & Girard). D.

Not common; similar to Iowa specimens. Scales 33.

8. **Semotilus atromaculatus** (Mitchill). D.

Common. Scales 60. Similar to Indiana examples.

9. **Rhinichthys dulcis** (Girard). H., D., M. (*Rhinichthys maxillosus* and *transmontanus* Cope. *Rhinichthys ocella* Garman.)

The Rhinichthys of the Rocky Mountain region strongly resembles the eastern *R. cataractæ*. It, however, differs constantly in the insertion of its dorsal, the front of the dorsal being midway between the base of the caudal and the nostril, while in *R. cataractæ* the base of the dorsal is almost midway between the base of the caudal and the tip of the snout. *R. dulcis* is usually rather more slender than *R. cataractæ* and has a sharper snout. It does not usually reach as large a size as the latter species. No difference in the fins; scales or coloration seem to be permanent.

The *Rhinichthys* of the upper Missouri, Arkansas, and Platte seems to be the same. That of the upper Rio Grande, called *R. transmontanus* by Professor Cope, is not evidently different. The species found in the Utah Basin (*R. luteus* Garman) has, as a rule, two or three more scales in a vertical row from dorsal to ventrals, twelve to fourteen below lateral line in *luteus*, ten or eleven in *dulcis*. But this character is variable and of rather doubtful value, and no other difference is apparent.

10. **Zygonectes floripinnis** (Cope). D.

One specimen taken, agreeing with Cope's description. Outer teeth long, well separated. Scales 31–10. D. 10. Scales of back much punctulate with black.

11. **Etheostoma nigrum** Rafinesque. D.

Abundant, apparently like Iowa specimens. D. IX—12. Scales 47.

12. **Salmo mykiss stomias** Cope. M.

Abundant in the Park Range and in mountain streams generally.

B.—ARKANSAS BASIN.

The Arkansas River rises in the mountains to the north of Leadville. It flows southward through a broad park-like valley, grassy in its upper part and becoming arid lower down. This valley is bounded on either side by lofty mountains, with snow-banks which are the source of many ice-cold streams. At Salida the river turns abruptly to the east, breaking through the mountains in a deep and rocky cañon, by which it reaches the level of the sage plains. Throughout the region above the cañon the Arkansas is clear and cold, in every way well suited for trout. Placer-mining at Leadville and Granite has much reduced the number of fishes in the river by filling the water with clay, but they still abound in all the tributary streams. Below the cañon the river becomes warmer and more muddy, and no trout are found there, the fauna from Cañon City down being much the same as that of the rivers of Kansas. The fishes of the Arkansas were examined at the following points:

1. *Arkansas River* and its Lake Fork near Leadville. (Seined at a bridge across Lake Fork between Evergreen Lakes and the village of Malta, about 3 miles west of Leadville.)—The river and the Lake Fork are about equal in size and entirely similar in character, flowing with a moderate current through green meadows, shaded by willows, and with occasional deep holes in the bends. The streams are each about 15 feet wide and the bottom is gravelly. The temperature is about 62°. These streams are ideal trout-brooks. Trout are very abundant and with them *Rhinichthys dulcis.* Species taken at Leadville are marked L in the following list.

2. *The Evergreen Lakes* are a series of trout-ponds, wholly or partly artificial, fed by cold streams from the flanks of Mount Massive. One of these streams, having its rise in the largest permanent snow-field in Colorado, has been chosen by the U. S. Fish Commission as the site of its hatchery. No better location could be desired.

3. *Twin Lakes.*—These two lakes, formed by a moraine-dam at the foot of Mount Elbert and Mount Grizzly, are the largest lakes on the east side of the divide in Colorado. The two lakes are separated also by a moraine, across which they are connected by a short stream, perhaps an eighth of a mile long. The lower lake is the larger of the two, and is about 3 miles long by 2 wide. The upper is about 1½ miles by 2. The lower lake is said to average 40 feet in depth, its lower part being extensively shallow, the middle and the south side very deep. The bottom is largely gravelly and covered with water plants. In some places are piles of boulders. The shallow north side of the lake is full of Najas and other water weeds, growing 3 to 5 feet high in water 10 feet deep. Among these plants the trout chiefly feed. In them they often escape after taking the fly by breaking the leader. "Shrimps" (*Gammarus*) are very abundant in the weeds. The upper lake is a little colder and not quite so well stocked with fish. Its area is about one-half that of the lower lake. Our collections were made in the lower lake, most of the trout being taken with the fly by Mr. George R. Fisher. Besides the two forms of trout, the lake contains suckers (*C. teres*) and *Rhinichthys dulcis.* Species from Twin Lakes are marked T in the list. The inlet of the upper lake is a very clear, cold stream of considerable size. A water-fall in this stream formerly checked the ascent of the trout, but it has now been destroyed by blasting.

4. *Lake Creek* near Granite.—Lake Creek, the outlet of Twin Lakes, is a very clear stream with green borders running across a desolate mesa, a glacial moraine, down to

the Arkansas River. It is about 2 rods wide and 2 to 4 feet deep. The temperature is about 73°. Its bottom is gravelly, rarely sandy, with some deep holes and with few water plants. Fishes are not plenty. Most were caught at the bridge, midway between the lakes and the Arkansas River, and about 1½ miles from either. The creek contains trout, suckers, and *Rhinichthys*, marked G in the list.

5. *Arkansas River* at Cañon City.—At Cañon City, at the foot of its great cañon, the river is somewhat turbid and has a temperature of 70°. The stream is rather swift, with gravelly bottom and no weeds. The bottom is muddy in places, doubtless from the placer mining above. The cañon marks the lower limit of the trout and the upper limit of the fishes of the plains. Fishes are scarce in the river here, the four species seen being marked A in the list.

6. *Pond at Cañon City.*—Opposite Cañon City is a small clear pond fed by sweepings from irrigating ditches, full of chara and other weeds. The water is warm, temperature 80°, and the pond and its small outlet is full of small fishes. The pond is 2 rods long and 3 feet deep. The species taken here are marked C in the list below.

7. *Grape Creek* above Cañon City.—Grape Creek is a small but long stream, rising in the Wet Mountain range, flowing in a narrow valley with precipitous walls, and emptying into the Arkansas from the south 2 miles above Cañon City. The water is clear and cold, temperature 66°. The current is swift and the bottom of sand and gravel without weeds. It is about 6 feet wide, 12 inches deep, with a few pools. In the deep places is *Rhinichthys dulcis.* No other fishes were seen. It is said that trout occur some 18 miles up the creek, but not in abundance. Four-Mile Creek, below the town, is a similar stream. Some seventeen years ago, we are informed, this stream was full of trout, but in a dry summer it was reduced to a series of pools. The settlers gathered the trout then with dip-nets and the herons took all that were left. Since then no trout have been seen there.

8. *Arkansas River* at Pueblo.—At Pueblo the river becomes warm, 80°, and dark gray in color. It is about 4 rods wide and 2 to 5 feet deep, with swift current. The bottom is gravelly, with stretches of gray mud. There are no deep pools or quiet reaches and no water plants. Fishes are plentiful, especially in the shoals. Collections were made at Good Night Ranch, 5 miles west of Pueblo, above and below Mr. Bell's residence. Close along the river the banks are green, but the region about is a hot, barren mesa, with scanty vegetation. Fishes from Pueblo are marked P in the list which follows.

9. *Fountain Creek* at Pueblo.—Fountain Creek is a long stream rising in the mountain brooks about Pike's Peak. It is formed at Manitou Springs by the union of two streams, the Ruxton, rising on Pike's Peak, and the Font-qui-Bouille, which rises in Ute Pass. The Ruxton, a mountain torrent, is without fish, but into a tributary pond eastern trout have been introduced. The Font-qui-Bouille, also without fish, has in its course both iron springs and water-falls. The iron springs give the water a red tinge. The waters of Fountain Creek are chiefly consumed by the irrigating ditches. At Pueblo it is a clear shallow stream, 6 feet wide by 4 inches deep, in a wide sandy bed. Temperature, 70°. Species from Fountain Creek are marked F.

10. *Arkansas River* at Wichita, Kans.—A collection comprising 27 species was made for us at Witchita by Mr. Sherman Davis. The river at Wichita is broad and muddy, with soft bottom, and the species obtained are mostly those of the muddy or sandy prairie streams of Kansas.

FISHES OF THE ARKANSAS BASIN.

A.—UPPER ARKANSAS ABOVE THE CAÑON.

1. **Catostomus teres sucklii** Girard. G., T. (*Catostomus alticolus* Cope; *Moxostoma trisignatum* Cope.)

Abundant in Lake Creek, and more or less common in the Twin Lakes. Similar to ordinary eastern specimens—var. *teres*—except that the lips are larger, and the upper lip has from four to six rows of papillæ. The fish called *Catostomus sucklii* by Girard belongs to this type, which may be known as var. *sucklii*.

2. **Rhinichthys dulcis** (Girard). L., T., G.

Abundant in all the streams tributary to the Upper Arkansas, in company with the trout, although not ascending the brooks as far as the lakes.

3. **Cottus** sp.

It is said that a species of *Cottus* is occasionally found in the Upper Arkansas, but we saw no specimens.

4. **Salmo mykiss macdonaldi** (Jordan and Evermann). The yellow-finned trout of Twin Lakes. (Plate I, Fig. 1.)

Besides the common green-back trout another trout has long been known to anglers to exist in Twin Lakes, and Messrs. Gordon Land and George R. Fisher have in one way or another at different times called attention to it.

Mr. Fisher accompanied me from Leadville in search of the fish, and a morning of fly-fishing secured for us about ten fine specimens. These represent a very distinct form or variety of the mountain trout, which we recognize as a distinct subspecies under the name of *Salmo mykiss macdonaldi*. We have taken pleasure in naming the yellow-fin for the U. S. Fish Commissioner, the Hon. Marshall McDonald, in recognition of his services in connection with the propagation of the American Salmonidæ.

It is not unlikely that this may prove to be a desirable variety for introduction into gravelly ponds and lakes in other regions.

Description.—Head, 4 to 4 1.10 in length; depth, 4 1.5 to 5. D. 2, 12. A. 1, 11. B. 10. Scales, 40–184–37; about 125 pores. Length of types, 6 to 10 inches.

Body more elongate and more compressed than usual among the trout. Head long, compressed, the snout moderately pointed; mouth rather large, the jaws subequal, the maxillary extending beyond the eye, $1\frac{3}{4}$ to 2 in head; hyoid teeth present, small; opercle longer than usual, its greatest length $4\frac{1}{3}$ in head, somewhat greater than eye, its posterior margin strongly convex. Eye $5\frac{1}{3}$ in head; snout $4\frac{1}{8}$; gill-rakers short, $x + 10$ in number.

Scales quite small and regularly placed. Pectoral fin moderate, $1\frac{2}{3}$ in head; ventrals 2. Caudal moderately emarginate, the lobes equal, $1\frac{2}{3}$ in head.

Color, silvery olive; a broad lemon yellow shade along the sides, lower fins bright golden yellow in life, no red anywhere except the deep red dash on each side of the throat, which is never wanting in *Salmo mykiss*. Body posteriorly and on dorsal and caudal fin profusely speckled with small pepper-like spots, smaller than the nostril and smaller than in any other of the forms of the *Salmo mykiss*. Occasionally these spots extend forward to the head, but they are usually sparse on the anterior half of the body.

The yellow-fin trout is largely on the gravels and about the north or sunny side of the lake. It is not often taken in deep water.

It spawns in spring, and the suckers devour the spawn in the streams and spawning beds. The trout, however, feeds freely on young suckers, and sometimes on young trout.

This species has the lower fins bright yellow; there is a broad yellowish lateral shade, by which the species can be recognized in the water. The black spots are numerous and very small. There is little red under the throat and none at all elsewhere. The flesh is paler and more watery than that of the green-back trout, which is usually regarded as the better food-fish. This paleness of color may be associated with its feeding habits, the trout which feed on crustacea having the redder flesh.*

5. **Salmo mykiss stomias** (Cope). Green-back Trout. (Plate I, Fig. 2.)

This trout is very common in all the upper tributaries of the Arkansas River and in the Twin Lakes. From the common trout of the upper Missouri region it seems to differ somewhat, being of a greener color, with less red, and with redder flesh, all matters of very slight importance from the point of view of the systematist. The black spots are larger than in any other of our trout. The mouth is rather small and the scales are smaller than usual among these trout.

These facts seem to indicate a distinction from the ordinary *Salmo mykiss* sufficient to justify the recognition of a subspecies, although the differences are small, and some of them may be inconstant. The trout taken by us in tributaries of the Platte seems to be identical with the "green-back trout" of the Arkansas. The name *Salmo stomias* was given by Cope to specimens at first stated by him to have come from the "Platte River, at Fort Riley." Later he stated that these came "not from the Platte, but from the Kansas, a very different river." Fort Riley is a town on the Kansas River, east of the center of the State of Kansas. The Kansas River rises in the sage plains of Eastern Colorado. It contains no trout anywhere. In fact, there are probably no waters in which trout can live within 500 miles of Fort Riley. It is safe to presume that the types of *Salmo stomias* did not come from Fort Riley. It is probable that

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* Since this report was sent to the printer, I have received from Mr. George R. Fisher, of Leadville, a very fine specimen of the yellow-fin trout. Mr. Fisher writes under date of June 2, 1890:

"I returned to Leadville in the spring and was here when the yellow-fins gathered at the mouth of the creeks immediately after the ice left the lakes waiting for the first rise in the streams. They appeared in schools at first but as the water raised they paired off, and went to the spawning beds in pairs.

"Before they mated they would take a trolling spoon or fly, and I believe grubs or minnow bait, but after pairing (they were nearly ready to spawn then) they would take nothing, and could only be taken with a grab-hook or spear. The largest yellow-fin taken this spring of which I know personally weighed 8 pounds 11½ ounces, and I believe that was the heaviest taken. This fish had been dressed before I knew of its capture or I would have sent it to you.

"I got one from two fishermen named Tyler and McDonald which weighed something over 7 pounds when first taken from the water, though I can't give the exact weight. This fish I have put in alcohol sealed up in a tin box and sent to you by express.

"It was kept on ice four days before putting in the alcohol and weighed at that time 6 pounds 14 ounces.

"This weight was carefully made and I know was correct.

"I have kept the fish here just one week since it was put in the alcohol and I see it has lost a good deal of the yellow color on the fins and throat."

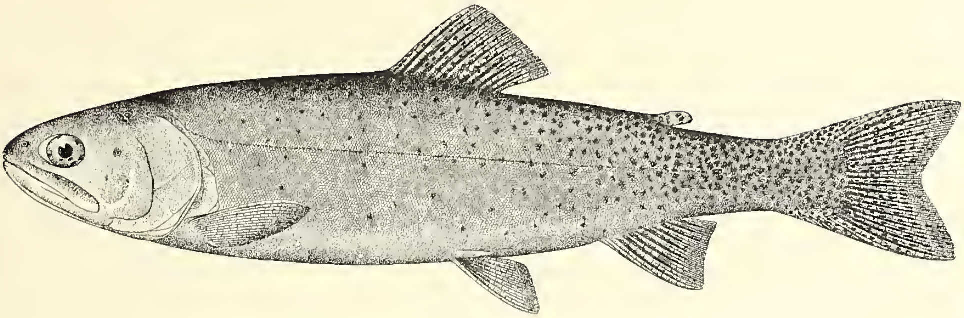


FIG. 1. YELLOW-FINNED TROUT (*Salmo mykiss macdonaldi*). (See page 11.)

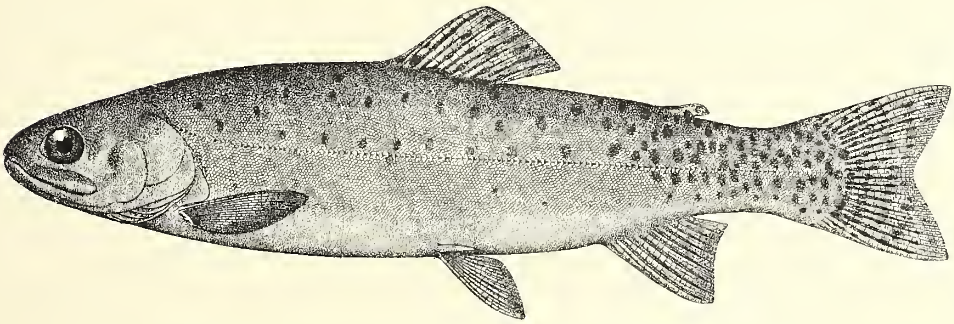


FIG. 2. GREEN-BACK TROUT (*Salmo mykiss stomias*). (See page 12.)

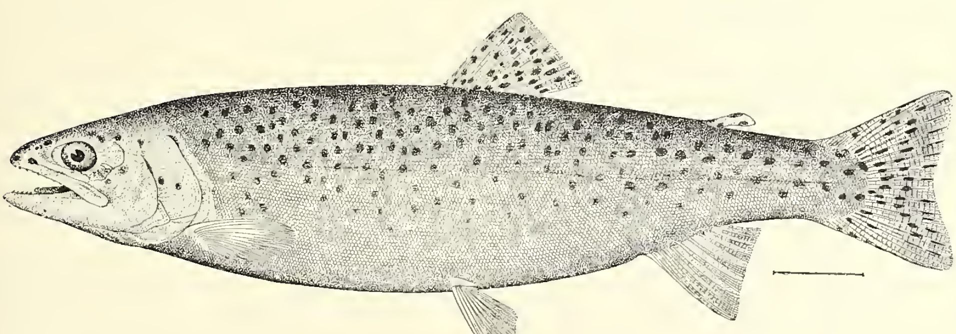


FIG. 3. RED-THROATED TROUT (*Salmo mykiss*). (See page 13.)

they came from some point on the South Platte, and on this supposition I have adopted the name *stomias* for the trout of the Platte.

The green back trout seldom exceeds three-fourths of a pound in weight. It is very abundant in the streams of the Upper Arkansas as well as in the Twin Lakes. It spawns in spring, in snow-water if possible, and it will leave spring-water to find snow-water. In winter, however, they seek for warmer waters. It is said that when the winter breaks up, the trout are too blind to see bait. In color, the green-back is green, or even almost black on the back. The lower fins and the throat are bright red, but there is not much trace of the red lateral band. The black spots are large and mostly confied to the posterior part of the body. In some cases these spots are ocellated with paler. At the spawning time, in May and early June, the males have much red, but later the sexes become similar. In specimens found about pools, there is often much red even in the summer. Those from the deeper parts of the lakes are always bright green, with a little red.

At the hatchery of Dr. Laws it appears that this trout will not willingly eat young suckers or minnows, its food being largely young crustacea.

The flesh in these trout is extremely red, this color being probably heightened by the character of its food. In the specimens from Arkansas River the body is plumper and softer than in those from Twin Lakes.

In connection with our study of these two forms I have had occasion to compare a large number of trout from various streams in the Rocky Mountains and westward. Besides the rainbow trout, *Salmo irideus*, which is chiefly confined to California, and the steel-head trout, *Salmo gairdneri*, found chiefly about the river-mouths in Oregon and northward, both of which species are characterized by the large size of the scales (from 130 to about 140), all our other western trout of the genus *Salmo* seem to belong to a single species. For this species the oldest scientific name is that of *Salmo mykiss* Walbaum (1792). To this name *Salmo purpuratus* (Pallas, 1811) and *Salmo clarkii* (Richardson, 1836) must give precedence.

This species is distributed from Kamtschatka and Alaska, southward to the mountains of Chihuahua, and eastward along the flanks of the Rocky Mountains so far as the clear water of the mountain goes. It seems to be absent in southern California, its place being taken by the *irideus*, but in all other suitable waters, excepting some streams in northwestern Wyoming, where water-falls keep it back, this trout may be found.

Several well-marked varieties occur in isolated lakes, and in general large streams or streams with a large food supply yield larger trout than small streams or streams with scanty food. All forms of *Salmo mykiss* have distinct hyoid teeth in life. All have a red dash below the lower jaw, from which comes the vernacular name of "cut-throat trout," and all show a small diffuse dark spot behind the eye.

A comparison of many specimens leads us to the recognition of the eight subspecies or varieties besides two others which I am scarcely able to define. It will be interesting to find out to what extent these forms will interbreed, and to what degree their peculiar characters will prove to be permanent when they are transplanted to other waters.

a. **Salmo mykiss** (Walbaum.) (Plate I, Fig. 3.)

The typical (*i. e.*, first known) form of the species, found in the waters, both fresh and salt, of Alaska and Kamtschatka.

Large, black-spotted, both fore and aft, and reaching a weight of 10 to 25 or 30 pounds. Sea-run specimens are much paler in color and grow larger.

b. Salmo mykiss clarki (Richardson). "Cut-throat Trout."

The common trout of both sides of the Cascade Range, profusely and usually rather finely spotted, the spots scarcely more numerous behind than before.

c. Salmo mykiss lewisi (Girard). Trout of the Upper Missouri. (Plate II, Fig. 4.)

This large trout seems to have the spots, on the average, larger than on those west of the mountains, but even this difference is questionable, and doubtless neither form requires a varietal name.

d. Salmo mykiss henshawi (Gill and Jordan). The trout of Lake Tahoe and neighboring waters. (Plate II, Fig. 5.)

A fine large trout, distinguished mainly by its longer and more conical head. Spots large, equally distributed, extending on head and belly. Scales rather small; about 180.

e. Salmo mykiss pleuriticus (Cope). Colorado River Trout. (Plate II, Fig. 6.)

The common trout of the basin of the Colorado, its range extending to the mountains of Arizona. Variable in color, size, and form, with its surroundings, and in most respects substantially identical with *lewisi*, the chief difference being that in this form, as in *spilurus*, *stomias*, and *macdonaldi*, the black spots are usually much more numerous on the posterior part of the body, while the head is usually free from spots. This is, however, not universally true.

In one specimen, from Trapper's Lake, the entire body from head to tail is closely and coarsely spotted. Generally the black spots are rather large, but in some specimens the spots are small, smaller than in any of the other forms except var. *macdonaldi*.

In a considerable number taken in Eagle River, Colorado, the spots are as small and as close set as in var. *macdonaldi*, and the usual red color of the lower fins is in these specimens changed to pale orange.

Although the coloration is almost that of *macdonaldi*, there are other differences, the most notable being in the short opercle, $4\frac{2}{3}$ to 5 in head ($4\frac{1}{3}$ in *macdonaldi*). The body is also less elongate than in *macdonaldi*.

In var. *pleuriticus* there is almost always a very distinct red lateral band, and the lower fins are more or less red.

f. Salmo mykiss spilurus (Cope). The Trout of the Rio Grande. (Plate III, Figs. 7 and 8.)

Abounding in all its tributaries and extending southward in the mountains to northern Chihuahua. This form is apparently wholly identical with var. *pleuriticus* except that in the specimens examined the scales are less crowded forward, so that the number in a lengthwise series is less. I count 155 to 160 in Rio Grande specimens; 185 to 190 in those from the Colorado. From the trout of the Great Basin (*virginalis*), *spilurus* differs chiefly in the arrangement of its spots.

g. Salmo mykiss virginalis (Girard). (*Salmo utah* Suckley.) The Trout of Utah Lake. (Plate III, Fig. 9.)

The trout of the Great Basin are profusely and not very coarsely spotted, the spots being numerous anteriorly as well as posteriorly, confined to the back rather than to the tail. In several examined, the scales are a little larger than in any of the other forms, 140 to 150 in a lengthwise series, the scales on the anterior part of

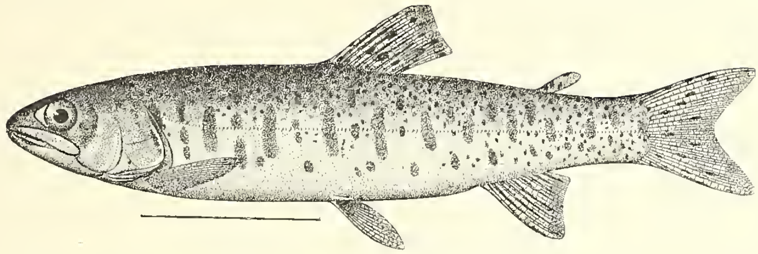


FIG. 4. RED-THROATED TROUT (*Salmo mykiss lewisi*). Young. (See page 14.)

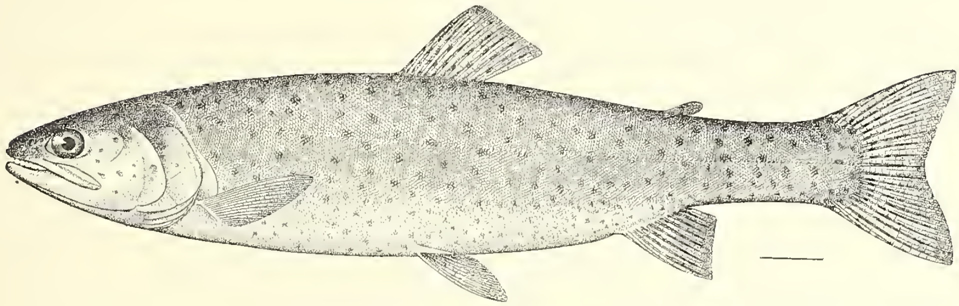


FIG. 5. LAKE TAHOE TROUT (*Salmo mykiss henshawi*). (See page 14.)

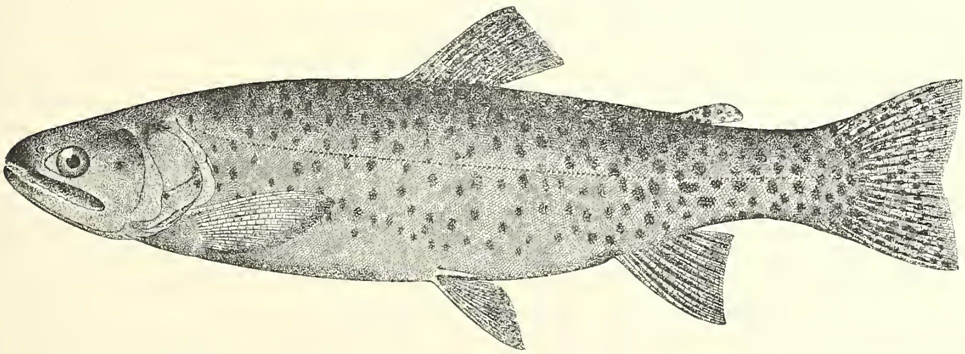


FIG. 6. COLORADO RIVER TROUT (*Salmo mykiss pleuriticus*). (See page 14.)

the body being less crowded than in *spilurus* and *stomias*. In other respects *virginalis* scarcely differs from *clarki*.

The large fishes from Utah Lake are very pale in color, the dark spots few and small, much as in var. *macdonaldi*, but fewer, and more on the back. This pale coloration is characteristic of lake and sea trout in general. It is doubtless partly due to the alkaline character of the waters of Utah Lake.

h. Salmo mykiss stomias (Cope). (Plate I, Fig. 2.)

Arkansas and Platte Rivers. A small trout, with very large black spots and small scales. It closely approaches *lewisi* and *spilurus*. The black spots are always larger than in any of these, and mostly gathered on the tail.

i. Salmo mykiss macdonaldi Jordan and Evermann. Yellow-finned Trout. In Twin Lakes. (Plate I, Fig. 1.)

The most strongly marked of these varieties so far as color and general appearance are concerned. The head is long and the opercles longer than in most of the others. Probably an early off-shoot, perhaps inhabiting these lakes prior to the advent of var. *stomias* in the same region. The nearest relative is *pleuriticus*, from which I think it is descended.

k. Salmo mykiss bouvieri (Bendire). (Plate IV, Fig. 10.)

In Waha Lake, in Washington, a mountain lake without outlet; a peculiar form, with short, blunt head, large eye, moderate (160) scales, and the spots confined to the posterior half of the body. This form seems to be an off-shoot from *clarki*.

The following table was taken from a number of specimens of partly grown trout, most of them from 8 inches to a foot in length (those from Utah Lake, Henry Lake, and Riddle Lake being larger). In the size of fins, number of gill-rakers, dentition, etc., no differences of any importance have been noticed.

	Head in length.	Depth in length.	Eye in head.	Maxillary in head.	Scales.	Spots.
Trapper's Lake (*spilurus*)	$4\frac{2}{5}$	$4\frac{2}{5}$	5	$1\frac{5}{6}$	189	Large, close, and chiefly posterior.
Gunnison River (*pleuriticus*)	$4\frac{1}{3}$	$4\frac{1}{5}$	5	2	188 (125 pores)	Large; chiefly posterior; a few on head.
Rio Florida (*pleuriticus*)	$4\frac{1}{5}$	$4\frac{2}{5}$	$4\frac{2}{3}$	2	185	Same; anterior spots smaller.
Rio Grande (*spilurus*)	4	4	$5\frac{1}{5}$	$1\frac{9}{10}$	155 (115 pores)	Large; chiefly on tail.
Rio Grande (*spilurus*)	$4\frac{1}{4}$	$3\frac{5}{6}$	5	2	160	Same.
Wallawalla (*clarki*)	$3\frac{5}{6}$	$4\frac{1}{4}$	$4\frac{3}{4}$	$1\frac{3}{4}$	177	Rather large; scattered almost equally.
Henry's Lake, Idaho (*clarki*)	$4\frac{1}{5}$	$3\frac{5}{6}$	5	$1\frac{3}{4}$	178	Small; very closely set, especially behind.
Riddle Lake, Wyoming (*lewisi*)	$4\frac{1}{5}$	$4\frac{1}{5}$	5	$1\frac{2}{3}$	170	Rather large; not close set; more numerous behind, but not confined.
Utah Lake (*virginalis*)	$3\frac{3}{4}$	$4\frac{1}{4}$	5	$1\frac{5}{6}$	148 (150 pores)	Small; mostly confined to back; few on tail.
Provo River (*virginalis*)	$3\frac{5}{6}$	$4\frac{1}{2}$	5	2	145 (121 pores)	Rather large; scattered equally.
Provo River (*virginalis*)	4	$4\frac{1}{2}$	5	2	141	Same.
Bear Creek, near Denver (*stomias*)	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{3}$	2	180	Large; largest on tail.
Twin Lakes (*stomias*)	$4\frac{1}{5}$	$4\frac{2}{5}$	$4\frac{3}{4}$	2	193 (140 pores)	Very large; well defined; largest on tail.
Twin Lakes (*macdonaldi*)	$4\frac{1}{10}$	$4\frac{1}{6}$	$5\frac{1}{3}$	2	184	Very small; smaller than nostril; most numerous behind.
	4	$4\frac{3}{4}$	$4\frac{1}{2}$	$1\frac{4}{5}$	183	Very small; most numerous behind.
Waha Lake (*bouvieri*)	$4\frac{1}{2}$	$4\frac{1}{3}$	$3\frac{1}{2}$	2	160	Large; all on the tail.
Eagle River (*pleuriticus*)	$4\frac{1}{10}$	$3\frac{5}{6}$	$4\frac{2}{3}$	$1\frac{5}{6}$	175	Very small; most numerous behind.

Besides the native trout, *macdonaldi* and *stomias*, the following trout have been introduced into the Twin Lakes.

Salvelinus fontinalis (Mitchill).

This species does well, growing faster than the native trout. It seems to prefer the colder waters of the upper lake.

Salmo irideus Gibbons.

This species is doing well, and is already becoming common.

Salmo salar sebago (Girard).

The land-locked salmon was introduced about 1885. They grow very slowly in the Twin Lakes, and rarely exceed one-half pound. They are occasionally taken.

ARKANSAS RIVER, BELOW THE CAÑON.

1. **Ameiurus melas** (Rafinesque). P.
Rather scarce.

2. **Catostomus teres** (sucklii Girard). A., P.
Everywhere common.

3. **Campostoma anomalum** (Rafinesque). A.
Scarce. *Campostoma aikeni* Cope, from Pueblo, is identical with *C. anomalum.*

4. **Pimephales promelas confertus** (Girard). A., P., C., F.
Very common in muddy shallows.

5. **Notropis scylla** (Cope). P.

In the river channel. Not common. This is the species recorded by Dr. Gilbert from Kansas as *Notropis deliciosus lineolatus.* *Notropis chlorus* (Jordan) is probably the same species. Agassiz's *lineolatus* may be this or some of the related species. The short description is insufficient to permit indentification, and the name should not be used. The same remarks apply also to Rafinesque's name *microstomus*, which I have elsewhere used instead of *stramineus* and the still older name *deliciosus.* *Notropis phenacobius* Forbes is identical with *N. scylla*, as I am informed by Dr. Gilbert, who has examined Dr. Forbes's types. *N. scylla* is close to *N. deliciosus*, but stouter in body with a shorter, blunter, and deeper head. Its scales are larger, but those before the dorsal are smaller and more crowded. Mouth small with subequal jaws, the cleft somewhat oblique. Head $3\frac{2}{3}$–$4\frac{1}{4}$; depth 4–$4\frac{1}{4}$; scales 31–33; 14–15 before dorsal; maxillary equal to eye, $3\frac{1}{5}$–$3\frac{1}{2}$ in head; snout 4. Pectoral nearly reaching ventral. Color pale, a dusky shade before dorsal and one on each side of the fin, as in *N. deliciosus*; some dark dots on side of snout; a faint dark lateral shade. In *N. deliciosus* the scales are 34–38, 12 before dorsal; eye, 3 in head; body and head more slender. Renewed comparison of specimens from White River, Indiana, with others from Rio Comal in Texas, confirms my belief in the complete identity of *N. deliciosus* and *N. stramineus.*

6. **Notropis lutrensis** (Baird and Girard). P., F.

Very common at Pueblo; some specimens highly colored; bodies blue, fins crimson.

7. **Rhinichthys dulcis** (Girard). P.
Abundant and large in the river and in Grape Creek. Fins often red.

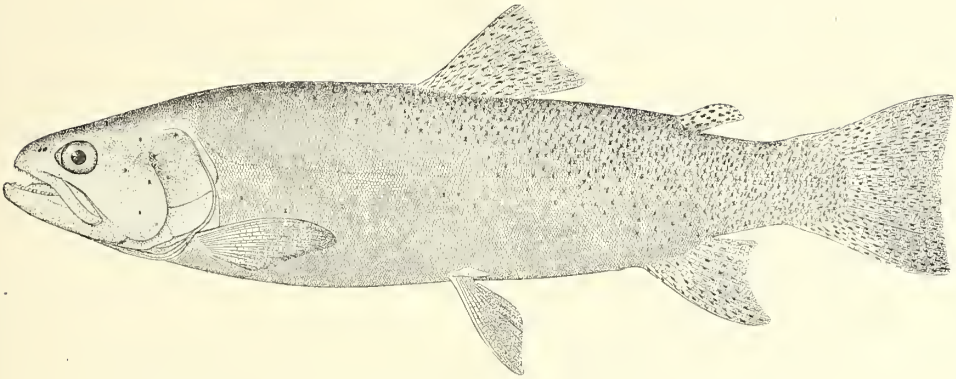


FIG. 7. RIO GRANDE TROUT (*Salmo mykiss spilurus*). Adult. (See page 14.)

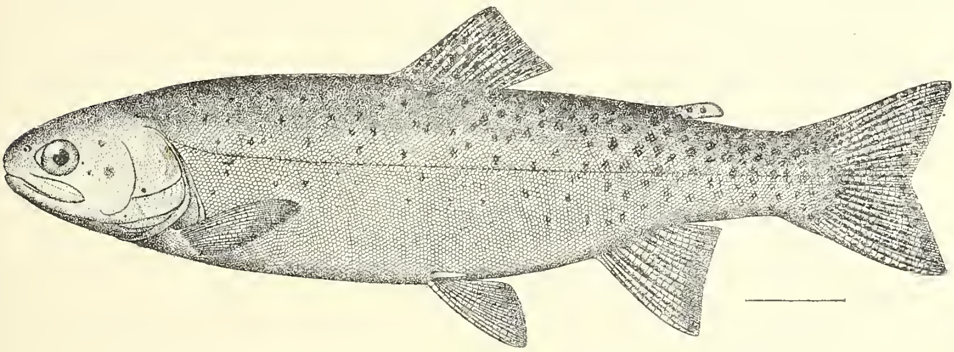


FIG. 8. RIO GRANDE TROUT (*Salmo mykiss spilurus*). Young. (See page 14.)

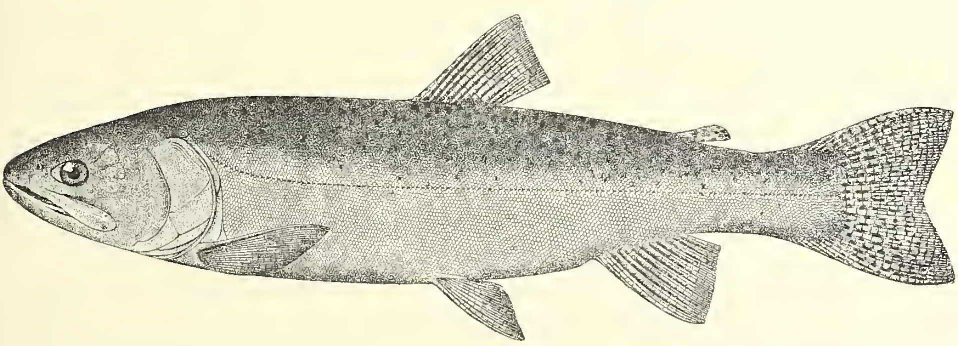


FIG. 9. UTAH LAKE TROUT (*Salmo mykiss virginalis*). (See page 14.)

8. **Platygobio physignathus** (Cope). A., F.

Very common, the most abundant species in the river. This species is a true *Platygobio*, not a *Couesius*. It differs from *P. gracilis* in having the head shorter, narrower, and blunter, less depressed above. Anterior profile forming a nearly even curve, which is everywhere convex. Head $4\frac{2}{3}$ in length, depth $4\frac{2}{3}$, scales 6–48–5, 20 scales before dorsal, snout 3 in head; teeth with distinct grinding surface. In *P. gracilis* the broad head is concave in profile above the eye. *P. pallidus* Forbes may be a valid species, but from the description I can not tell it from the young of either of the others. Our specimens from St. Joseph, Mo., seem to be *P. gracilis*.

9. **Hybognathus nuchalis** Agassiz (var. placita). P.

Not rare in the river.

10. **Hybopsis tetranemus** Gilbert. P.

One specimen of this singular little fish. Barbels long, the second pair nearly as long as the eye. Some of the specimens from the Arkansas basin, recorded by Jordan & Gilbert as *Hybopsis æstivalis*, belong to the species.

11. **Fundulus zebrinus** Jordan & Gilbert. F., C.

Very common in brooks and the pond; not seen in the river.

12. **Lepomis cyanellus** (Rafinesque). C.

One found in the pond at Cañon City.

13. **Etheostoma cragini** Gilbert. C.

Very abundant in the pond at Cañon. Head naked; fins with brick-red shades; body with blue specks in life; body and fins profusely punctulate with black.

C.—ARKANSAS RIVER AT WICHITA.

1. **Ameiurus melas** (Rafinesque).
2. **Ictalurus punctatus** (Rafinesque).
3. **Ictiobus bubalus** (Rafinesque).
4. **Ictiobus difformis** (Cope).

Numerous specimens; the dorsal rays low, little longer than head and stout at base. Eye $4\frac{1}{2}$ in head. Snout short, very blunt.

5. **Moxostoma duquesnei** (Le Sueur).

Head $4\frac{2}{3}$ in length in one example, and head $4\frac{1}{4}$ in another.

6. **Campostoma anomalum** (Rafinesque).
7. **Hybognathus nuchalis** Agassiz.

Numerous examples of the ordinary type.

8. **Pimephales promelas confertus** (Girard).

Scarcely if at all different from the common *promelas*.

9. **Pimephales notatus** (Rafinesque).
10. **Cliola vigilax** Baird & Girard.
11. **Notropis scylla** (Cope).

Abundant.

12. **Notropis cayuga** Meek.

Abundant. This is a widely diffused species, allied to *N. heterodon*, from which it is easily known at sight by the absence of black on the chin. Head, $4\frac{1}{6}$ in length; depth, $4\frac{1}{2}$; scales, 36; 14 before dorsal; lateral line wanting on some scales; mouth

very small, anterior, the maxillary not reaching to eye; eye large, equal to snout, 3½ in head; jaws, subequal; scales above, dark-edged, very sharply defined; a black stripe through snout and eye, with a dusky lateral shade and a small caudal spot. *Notropis frctensis* (Cope) may be this species, but the short description applies as well to *N. heterodon*. Some of the references to *heterodon* may belong to *N. cayuga*. Among the specimens taken by Dr. Gilbert and the writer in Rio Comal at New Braunfels, Tex., is one not mentioned in our paper (Proc. U. S. Nat. Mus., 1886, 23) closely resembling *N. cayuga*, but with the snout a little more blunt in profile; the scales, form, and coloration being the same. Another in Dr. Gilbert's collection (Long Lake, Ill., Harrison Garman) agrees fully with this one, but we are unable to decide whether the species they represent is different from *Notropis cayuga*.

13. **Notropis camurus** Jordan & Meek.

Very abundant.

14. **Notropis bubalinus** (Baird & Girard).

One example. More elongate than the species described, but if the variations in this species are the same as in the allied *lutrensis*, this has little significance. Head, 4 in length; depth, 3½; scales 36; 18 before dorsal. Closely related to *N. camurus*, but the dorsal without black blotch; scales a little smaller and less closely imbricated; head a little smaller.

15. **Notropis lutrensis** (Baird & Girard).

16. **Notropis umbratilis** (Girard).

17. **Notropis topeka** Gilbert.

A few specimens.

18. **Phenacobius mirabilis** (Girard).

Typical; scales, 49; their outlines obscure.

19. **Hybopsis storerianus** (Kirtland).

Abundant.

20. **Hybopsis tetranemus** Gilbert.

Seven examples.

21. **Dorosoma cepedianum** (Le Sueur).

22. **Labidesthes sicculus** Cope.

Common.

23. **Lepomis humilis** (Girard).

Common.

24. **Lepomis cyanellus** (Rafinesque).

25. **Lepomis megalotis** (Rafinesque).

Specimens small, and with a black spot on last ray of dorsal, as in Texan examples.

26. **Etheostoma caprodes** Rafinesque.

27. **Etheostoma lepidum** Baird & Girard.

A few; head scaleless.

C.—RIO GRANDE BASIN.

The Rio Grande rises in the Saguache and Sangre de Cristo Mountains, at the head of San Luis Park. Its headwaters and its various tributaries are clear and cold, flowing through grassy mountain pastures, and being well stocked with trout. Of its upper tributaries, the following are all noted as trout streams, although the lower waters of all are consumed by the irrigating ditches: Saguache, San Luis, Madenha, Crestone, Piedras, Alamosa, La Jara, Conejos, Pinos, Ute, Sangre de Cristo, Trinchara, Costilla, Culevra, and Chama. In these streams thousands of trout are destroyed each year by the irrigating ditches, especially at the time of their downward migration in the fall. It is stated that nine-tenths of the trout in the San Luis Park have been thus destroyed. The streams of the northeastern part of the park (Madenha, Crestone) sink into the great sand dunes, the water rising from below as artesian springs, while the waters of the Saguache and the San Luis are lost in the alkaline San Luis lakes. Collections were made at the following points:

1. *Rio Grande* at Del Norte.—The Rio Grande here is a clear, full stream, with numerous trout, as well as chubs, minnows, and suckers. Temperature, 59°. The best trout fishing is found still higher up, about Wagon Wheel Gap. More trout are destroyed in ditches about Del Norte than anywhere else in Colorado. Species from Del Norte are marked D.

2. *Rio Grande* at Alamosa.—The stream here is quiet, with a bottom of adobe. The water is clear and rather cold (62°). In summer the stream is reduced to the seepage of irrigating ditches. In the deeper parts are multitudes of suckers and chubs. Species from Alamosa are marked A.

3. *Rio Conejos* at McIntyre's Ranch, about 15 miles south of Alamosa.—The clear stream is here 10 to 20 feet wide and 2 inches to 6 feet deep. The bottom is gravelly; the temperature 65°. Species taken here are marked C.

4. *Rio Chama* at Chama.—A clear, cold mountain stream, among those in southern Colorado best suited for trout.

5. *San Luis Lakes.*—Some 20 miles northeast of Alamosa there is a large depression in the plain. Into this flow several trout streams, the chief of these being the Saguache, San Luis, Madenha, and Crestone. The lower parts of this depression are occupied by the San Luis Lakes, but in ordinary summers none of these streams reach the lakes, the water either sinking into the sand or else being used in irrigation. The lakes are some six in number, ranging from 50 rods to 1 mile in length, filling one after another from the rains and from the soakage of the streams. They are connected by a broad ill-defined channel, usually dry, which extends to the Rio Grande, below Alamosa. The lakes are all strongly alkaline. The two examined were strongly impregnated with soda, and without fishes or any other animals. The uppermost is said to be less alkaline, but evidently all are worthless for fishes.

FISHES OF THE RIO GRANDE.

1. **Pantosteus plebeius** (Baird & Girard) D., C., A.; *Catostomus guzmaniensis* Girard; (*Pantosteus jarrovii* Cope & Yarrow; not *Minomus jarrovii* Cope).

Very abundant everywhere, especially in the deeper places and eddies, reaching a length of about a foot.

This is the species well figured by Cope and Yarrow under the name of *Pantosteus*

jarrovii, from the Rio Grande. The original *Minomus jarrovii* of Cope is from Provo, Utah, and is the species described by Girard as *Acomus generosus*, and by Cope as *Minomus platyrhynchus.* The original *Catostomus guzmaniensis* and the original *Catostomus plebeius* are from Lake Guzman, in Chihuahua, a lake without outlet, but belonging to the Rio Grande Basin.

Among the many specimens of *Pantosteus* examined by us we recognize three species, each one, so far as our own collections show, confined to a distinct river basin. The following analysis shows the principal characters of each of these:

a. Scales moderate, 80 to 90 in the lateral line, 28 to 30 in a cross series between dorsal and ventral; mouth and lips of moderate size; dorsal rays usually 9.

b. Head comparatively short and small, $4\frac{5}{6}$ to 5 in length of body; body slender, the depth 5 to $5\frac{2}{3}$ in length; 45 to 50 scales before the dorsal; scales 15–18–14. Great Basin of Utah (*generosus* Girard=*platyrhynchus* Cope=*jarrovii* Cope) .... *Generosus.*

bb. Head comparatively large, $4\frac{3}{5}$ to $4\frac{2}{3}$ in body; body more robust, the depth $4\frac{3}{5}$; dorsal fin a little higher and pectoral a little longer. Rio Graude Basin and Lakes of Chihuahua (*plebeius* Baird and Girard= ? *guzmaniensis* Girard=*jarrovii* Yarrow, not of Cope).......... *Plebeius.*

aa. Scales very small, 95 to 103 in the lateral line; 20 to 33 in a cross series between dorsal and ventral; mouth large, with very full lips; head rather short, $4\frac{3}{5}$ to $4\frac{3}{4}$ in length; tail very slender, the caudal long; 50 scales before dorsal; depth of body about 5 in length; scales 16–96 to 99–14. Basin of Colorado River (*delphinus* Cope = ? *bardus* Cope = *virescens* Cope = *guzmaniensis* Jordan Cat. Fish. N. A., 1885, probably not of Girard)................. *Delphinus.*

These three species are certainly distinct from each other and are very common, each in its respective hydrographic basin. If other species exist they are unknown to us.

2. **Leuciscus pulcher** (Girard). C., A., D.

(*Gila pulchella* Baird & Girard, Proc. Ac. Nat. Sci. Phila., 1854, 29, Rio Mimbres, Lake Guzman, Chihuahua, not *Leuciscus pulchellus* Storer; *Tigoma pulchra* Girard, Proc. Ac. Nat. Phila., 1856, 207, Chihuahua R.; *Clinostomus pandora* Cope, Hayden's Geol. Survey Montana for 1871, 475, 1872, Rio Grande in New Mexico.)

The chub or "Pescadito" is everywhere abundant, reaching a length of 6 or 8 inches. It is found in eddies and deep places with the preceding species. The synonymy of the species is given above. There seems to be little room for doubting the identity of *pulchella*, *pulchra*, and *pandora*, and no other species of this genus has yet been authentically recorded from the basin of the Rio Grande. The earliest name, *pulchellus*, is preoccupied in the genus *Leuciscus.*

Head $4\frac{1}{5}$ in length; depth $4\frac{2}{5}$; scales 15–67–10; axils red in the male. Teeth often irregular in number, sometimes 1, 4–4, 1.

NOTE ON THE GENERIC NAME LEUCISCUS.

For a number of years American writers have referred our species with the teeth 1 or 2, 4–5, 2, and with hooked tips, to the genus *Squalius* Bonaparte.

Comparing the American species with the European representatives of this type, we find that while there is a general agreement in technical characters the European species have much larger and looser scales, and the scales have the radiating striæ more prominent. The European species have in fact the same squamation as our genus *Notemigonus.* The teeth in *Squalius* proper are 2, 5–5, 2, in all species, so far as examined.

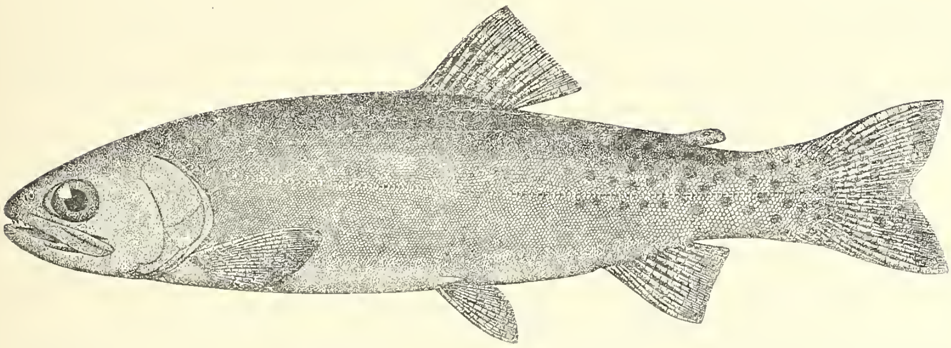


FIG. 10. WAHA LAKE TROUT (*Salmo mykiss bouvieri*). (See page 15.)

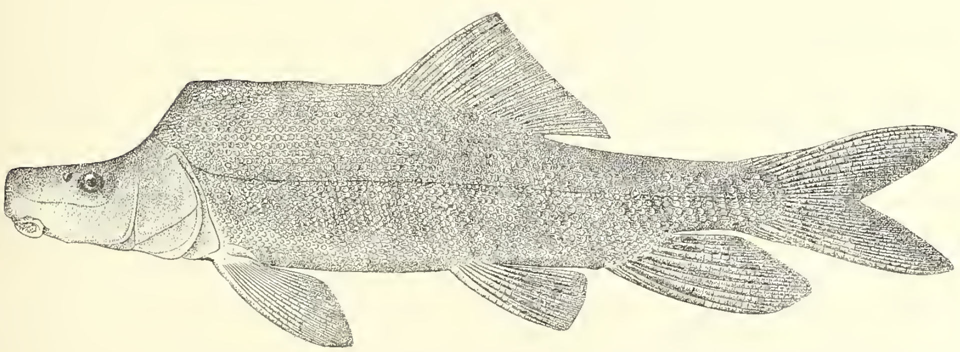


FIG. 11. HUMP-BACK SUCKER (*Xyrauchen cypho*). (See page 26.)

There is, however, in Europe a subgeneric group called *Telestes* by Bonaparte, which approaches much more nearly to the American forms. The scales in *Telestes* are small, ranging from 60 to 80, and the teeth are 2, 4–5, 2. I know of no character by which the American species called *Tigoma* can be set off from *Telestes*, nor does any definite character exist by which *Siboma*, *Cheonda*, and *Clinostomus* can be separated from *Tigoma*. *Protoporus* Cope is apparently also based on a young *Tigoma*.

It is, however, true that European writers generally hold the distinctions between *Telestes* and *Squalius* as of very slight value, and the figures and specimens accessible to us seem to show a pretty regular graduation from one type to the other. Nevertheless, no American species of this type is a near ally to *Squalius cephalus*, and none have the pharyngeal bones equally armed with 5 teeth in the main row so far as we know. For the present we may unite *Tigoma* with *Telestes* and *Squalius* as forming a single genus.

It seems to me, however, that the name *Leuciscus* should be used instead of *Squalius* for the group typified by *Leuciscus cephalus* and *L. leuciscus*.

The generic name *Leuciscus* was first applied by Cuvier in 1817 to a group of Cyprinoids about corresponding to the *Leuciscinæ* of present classifications. Five species are mentioned especially by Cuvier in his text, and several others are referred to incidentally in a foot-note. Among the five mentioned in the text the type of this genus *Leuciscus* must be chosen.

These species are *Cyprinus dobula* L., *C. rutilus* L., *C. leuciscus* L., *C. alburnus* L., and *C. phoxinus* L.

In the Ichthyologia Ohiensis, 1820, Rafinesque adds numerous American species to the genus *Leuciscus*, proposing for them the new generic names of *Minnilus*, *Luxilus*, *Plargyrus*, and *Pimephales*. At the same time he divides the European species into five genera, *Dobula*, *Rutilus*, *Leuciscus*, *Alburnus*, and *Phoxinus*, the names and order corresponding to the order of the species as given by Cuvier. These genera are each briefly defined, but no typical species is mentioned, except in one case, a page or two later, where he speaks of *Cyprinus rutilus* L. as the type of *Rutilus*.

By Rafinesque's arrangement *Cyprinus rutilus* is made the type of *Rutilus* and *C. leuciscus* that of the restricted genus *Leuciscus*.

Later, Agassiz, not noticing the work of Rafinesque, similarly restricted *Leuciscus* to the species having two rows of teeth, *Rutilus* having but one.

Still later, Bonaparte made *Cyprinus leuciscus* the type of his restricted genus *Leuciscus*, and added *Scardinius*, *Squalius*, and *Telestes* for other species, the group called *Squalius* practically corresponding to the *Dobula* of Rafinesque, which is doubtless identical also with Rafinesque's *Leuciscus*.

At about the same time Heckel made more thorough investigations of the characters of these fishes than any of his predecessors had done. In his arrangement, *Cypr. dobula* and *Cypr. leuciscus* were referred together to *Squalius*, while the name *Leuciscus* was transferred to *L. rutilus*. The system of Heckel has been generally followed by later writers, although by Günther and others all these groups have been regarded as simple sections or subgenera under *Leuciscus*.

It seems evident that *Cyprinus leuciscus* must stand as the type of *Leuciscus*, and that the generic name of *Cypr. rutilus* must be *Rutilus*.

The genera concerned would then be:

1. *Leuciscus* (Cuvier), Rafinesque, Agassiz, and Bonaparte = *Dobula* Rafinesque =

Squalius Bonaparte, (probably including *Telcstes* Bonaparte = *Tigoma*, *Cheonda*, *Siboma*, and *Clinostomus* Girard and *Protoporus* Cope).

2. *Rutilus* Rafinesque (= *Leuciscus* Heckel, Günther = *Leucos* Heckel = *Pigus* Bonaparte; possibly should include *Myloleucus* Cope) species with the teeth 4–5 instead of 5–6 or 5–5, as in *Rutilus*.)

3. *Alburnus* Rafinesque = *Alburnus* Heckel.

4. *Phoxinus* Rafinesque = *Phoxinus* Agassiz.

For the present, at least, until better definitions can be given, we may refer the American species to the genus *Leuciscus* in which they form a subordinate group (*Tigoma* or *Telcstes*) distinguished by the smaller number of teeth and the generally smaller scales.

3. **Rhinichthys dulcis** (Girard), A., D., C. (*Rhinichthys transmontanus* Cope.)

Very common. We are unable to distinguish our specimens from the Rio Grande, from those taken by us in the Arkansas, Platte, and Yellowstone. As the types of *Rhinichthys transmontanus* are from New Mexico, we regard the latter species as a synonym of *R. dulcis*. *Rhinichthys maxillosus* Cope, originally described from Kansas, is the same as *R. dulcis*.

4. **Salmo mykiss** Walbaum, D., C. (Var. **spilurus** Cope.)

Abundant in the upper Rio Grande, and in all tributary streams down to the level of the valley.

The Rio Grande trout have the dark spots rather large and more or less confined to the dorsal and caudal fins and the region between them, though often, especially in the young, extending on the head. They reach a fair size, a pound or two in weight, but are doubtless not as large as the trout of the Upper Colorado. The Rio Grande trout was first described as a distinct species by Professor Cope under the name of *Salmo spilurus*. The types of this nominal species came from the Sangre de Cristo.

D.—COLORADO BASIN.

The Colorado River is formed by the union of two large rivers, Green River and Grand River. Both of these have their source in the mountain streams of the western slope of the Rockies, and are very clear and cold in their upper courses. Lower down they become gradually turbid and yellow and finally the Colorado becomes one of our muddiest streams. The headwaters everywhere are full of trout, and all the tributary lakes, many of which exist in northwestern Colorado, are especially well stocked. The fish fauna of this great river is very scanty. In the highlands the trout is accompanied by *Agosia* only. Lower down the "Blob" appears; still lower the suckers, four species in all in the upper waters, and with them the Round-tail (*Gila robusta*) and the "White salmon" (*Ptychochcilus*). This is the largest and best food-fish of the Lower Colorado and the largest of the carp family in America. The Bony-tail (*Gila elegans*) is found still lower down, while in Arizona the fauna is further increased by the addition of three or four more suckers and of species of *Leuciscus*, *Meda*, and other genera of chubs and minnows. Collections were made by us at the following localities:

1. *Grand River*, at Glenwood Springs, Colo.—The Grand River rises in the middle of northern Colorado flowing southwestward through deep gorges. Glenwood Springs lies at the foot of its deepest cañon. The water is here yellow and muddy, but the

clay comes chiefly from the placer mining above. The stream at Glenwood is broad and swift, while the bottom is full of large boulders so that it can not be easily seined. Two large suckers (*C. latipinnis*) were taken here. It is said that these suckers in winter come here for the warmth of the Hot Springs.

2. *Sweetwater Lakes* in Eagle County, Colo.—Some 25 miles above Glenwood are the Sweetwater Lakes, noted for trout. Several specimens of these trout were procured from fishermen.

3. *Trapper's Lake*, in Garfield County, Colo.—This is a noted locality for trout fishing, in the mountains some 40 to 50 miles north of Glenwood. Several fine examples of these trout were procured from anglers.

4. *Eagle River.*—This is a very clear, cold stream, flowing into Grand River from the east. It is very well stocked with trout, large numbers being taken with the fly. At Gypsum, where our collections were made, the river is about 20 feet wide and 2 to 4 feet deep. The bottom is rather smooth, but the water is too cold for seining. At this point, besides trout, are found *Cottus*, *Pantosteus*, and *Agosia*, the *Cottus* being excessively abundant.

5. *Roaring Fork of Grand River.*—The Roaring Fork rises in the mountains, above Aspen, and enters the Grand from the south near Glenwood. It is very clear, but not very cold (temperature 67°). Its lower course is swift, its channel filled with boulders washed from the great moraine through which it breaks its way. It is about 2 rods wide and 2 to 4 feet deep. Seining is impossible. Suckers (*C. latipinnis*) and blob were taken here. The stream is said to be well stocked with trout.

6. *Cañon Creek.*—This is a small stream flowing into the Grand below Glenwood. Some trout from this stream were secured from a fisherman.

7. *Gunnison River*, at Gunnison, Col.—The Gunnison is the chief tributary of the Grand, entering it from the south at Grand Junction. The Gunnison rises on the west slope of the Main Divide. Its upper course is largely quiet, flowing through mountain pastures with willow-covered banks. Below Gunnison it cuts its way through the Black Cañon, one of the deepest in Colorado. Above the cañon the river is very clear and full of trout, but one other species (*Agosia*) going with it. Below the cañon the water is warmer and less clear; trout are scarce and suckers and round-tails become abundant. The river at Gunnison is swift, with gravelly or rocky bottom; some 3 rods wide and 2 to 4 feet deep. In the cañon are many rapids and pools 6 to 20 feet deep.

8. *Tomichi Creek*, near Gunnison.—This is a clear stream about 6 feet wide and 2 to 20 inches deep, flowing in many windings with little current and with grassy banks covered with small bushes. It is not so cold as the river (about 72°); its bottom has a good deal of black muck. White ranunculus and other water-weeds abound and the stream much resembles a New England trout brook.

The Eastern brook trout (*Salvelinus fontinalis*) was successfully introduced into Tomichi Creek about 1883. Both this and the native trout were abundant in the upper course of the stream, but at Gunnison the waters are crowded with *Agosia yarrowi* and have no other fish.

9. *Rio Cimarron.*—This stream flows into the Gunnison in the Black Cañon. In the pastures above Cimarron station (2 miles above its mouth) it is a good trout stream. At Cimarron the stream is clear and swift with a bottom of gravel and small boulders

about 12 feet wide and 1 to 4 feet deep. Temperature 68°. No fishes were obtained with the net.

10. *Gunnison River*, at Delta, Colo.—At Delta, some distance below the Black Cañon, the Gunnison is a large stream 3 to 4 rods wide and 2 to 5 deep, the waters clear and of a summer temperature of about 72°. Its current is swift, and in its broad channel are many islands. The bottom is gravelly or sandy, and in still places occasionally muddy. The fishes here are the "Razor-back" or "Hump-back sucker" (*Xyrauchen cypho*), the "Flannel-mouth sucker" (*Catostomus latipinnis*), the "Blue-head sucker" (*Pantosteus delphinus*), the "Bony-tail" (*Gila elegans*), the "Round-tail" (*Gila robusta*), the "White Salmon" (*Ptychocheilus lucius*), the "Bull-head" (*Cottus bairdi punctulatus*) and the minnow (*Agosia yarrowi*).

11. *Uncompahgre River*.—This stream rises in the wild Uncompahgre Pass, above Ouray. In its upper course, it has few or no fishes, for it flows through wild and deep ravines with many cascades. Besides this, it has iron springs among its feeders, and trout seldom or never live in iron waters. Above Ouray, are some hot springs, and at Ouray stamp-mills render the water impure. Below Ouray are some trout, but probably not many.

Between Ouray and Montrose, the stream leaves the mountains, and from Montrose to its mouth at Delta, it is very sluggish and its waters are largely drawn off by the irrigating ditches. The plain is largely alkaline, and the banks of the stream are lined with greasewood (*Sarcobatus vermiculatus*), the sure indication of an alkaline soil. At Delta the only water left is from the seepage of ditches. This is grayish yellow, and forms a succession of pools with bottom of gravel or mud, some of them 5 or 6 feet deep. Temperature 78°. The water is full of fishes of the species enumerated above as found in the Gunnison. *Gila elegans*, *Agosia*, and *Cottus* were not seen in the Uncompahgre. On the other hand, a single specimen of what seems to be a new species of *Xyrauchen* was taken in the little pond close to the station at Delta.

12. *Green River*, at Blake City (Green River Station), Utah.—At this point the river flows through a barren desert, its course largely bounded by high cliffs. Its waters are yellow, and except on certain rocky shallows deep and sluggish. At low water the river is about 500 feet wide and 3 to 8 feet deep. In August the water was moderately clear, but at the time of the spring floods it becomes a paste of red mud. We seined the stream along the west side from the railroad bridge to the foot of the shallows about one-fourth mile below. *Xyrauchen cypho* is very abundant, reaching a weight of 10 pounds, and is a good food-fish. *Catostomus latipinnis* reaches 3 to 5 pounds. Besides these we obtained *Gila elegans*, a small fish regarded as worthless because full of bones. The trout do not descend Green River much if any below the boundary of Wyoming Territory.

13. *Price River* flows into the Green River from the west. It rises near the summit of the Wahsatch range. It soon becomes gray and muddy and when it strikes the desert at the eastern foot of the mountains its waters are all used for irrigation. Although a long river, its waters are nearly all lost in summer, and it is worthless for fish. It is said that trout occur in some ponds on the eastern slope of the Wahsatch.

14. *San Juan River*.—The San Juan is one of the chief tributaries of the Colorado, having its source in a considerable number of large, clear mountain streams, which head in the mountains of southwestern Colorado (Sierra San Juan, etc.), to the west of

the Main Divide. All these streams are well stocked with trout, their fauna being precisely like that of the Gunnison.

The lower San Juan enters the desert country and receives large numbers of "sand arroyos," dry beds flooded with mud after a rain. The water becomes warm, thick, and yellow, although all the upper sources of the river are clear and cold.

It is thought that the lower San Juan and the Colorado would be well suited for the growth of the larger cat-fishes as *Leptops olivaris*, *Amciurus nigricans*, and perhaps *Ictalurus punctatus*. It would be well to make a plant of these at Green River Station, and one on the San Juan at Arboles.

15. *Rio de las Animas Perdidas.*—The Animas River is the largest tributary of the San Juan. It rises in the mountains above Silverton. Above its cañon of "Lost Souls," it is clear, shallow, and swift, flowing through an open cañon with a bottom of rocks. In its upper course it is said to be without fish, one of its principal tributaries, Mineral Creek, rising in Red Mountain and Uncompahgre Pass, being highly charged with salts of iron.

In the deep and narrow "Cañon de las Animas Perdidas" are many very deep pools, said to be full of trout. Below the cañon is "Hermosa Park," in which, for some 15 miles, the river flows over sandy bottom, with many deep holes and slight current. In these holes are many trout, and with them *Pantosteus delphinus*, *Agosia yarrowi*, and *Cottus bairdi punctulatus*.

At Animas City, above Durango, the stream enters a stony mesa, a glacial moraine, which, by its dam, has formerly made a lake of Hermosa Park. From this point, for miles below, the bottom is so covered with boulders that seining is impossible. At Durango the river is 2 to 3 rods wide and 2 to 4 feet deep; in the deeper holes, 6 to 8. The temperature is about 68°. The stream was seined at various places from Animas City to a point about 5 miles above Durango.

At Durango it is said that the larger suckers (*X. cypho*, *C. latipinnis*) and the "White salmon" (*Ptychocheilus*) ascend the river in the spring, going back to deep water after spawning in the summer.

16. *Leitner's Creek*, at Durango.—This is a little stream entering the Animas opposite Durango. In summer it is 2 to 3 feet wide, shallow, clear, and warm (72°) with sandy bottom. It contains *Cottus bairdi punctulatus* and *Agosia yarrowi*. Higher up its deeper pools are said to contain small trout.

17. *Rio Florida.*—This is a clear, cold stream, flowing into the Animas below Durango. It was seined at several points above the bridge about 8 miles east of Durango and north of Florida Station. It flows through a wooded valley over round boulders and with few deep places. Trout are abundant; also *Pantosteus delphinus*, *Agosia yarrowi*, and *Cottus bairdi punctulatus*. The last-named species lurks under every stone in the river.

18. *La Plata River.*—West of the Animas River is the Rio la Plata. It rises in the mountains above Fort Lewis, but the water mostly sinks in the sand and gravel below the fort. There are some trout here, but it is said that the stream contains too much iron to be well adapted for fish. It was not visited by us.

19. *Rio de los Pinos* (seen at Ignacio), the next river east of Rio Florida, is a clear, swift stream, with gravelly bottom, 2 rods wide and 1 to 3 feet deep. It runs through a broad valley which may become valuable for agriculture. I am told that Patrick

Brothers have a trout hatchery further up the river at Los Pinos. Like the Animas, this is an excellent trout stream.

20. *Ignacio Lakes.*—Near Los Pinos River are the San Ignacio Lakes, one of 60 acres, one of 40 acres, at 8,000 feet elevation. They are fed by springs and have no outlet. They have no fishes but are said to be "full of dog-fish (*Amblystoma ?*) which devour the young trout which have been several times placed in the lakes." We were unable to verify this statement which was made by a citizen of Durango.

21. *Rio de las Piedras*, said to be the best trout stream in the San Juan basin, is similar to Los Pinos, but smaller.

22. *Rio Navajo*, which flows into the San Juan near Juanita, is also similar; a clear stream with gravelly bottom and wooded banks.

23. *Rio San Juan*, which receives the waters of all these, is, when crossed by the railroad at Arboles, about the size of Los Pinos at Ignacio. Its water is warm and not quite clear; the bottom of gravel and stones. About Pagosa Springs, above Arboles, it is a trout stream. Below Arboles it becomes very yellow, and at last it bears a volume of very muddy water into the Colorado.

FISHES OF THE UPPER COLORADO BASIN.

1. **Catostomus latipinnis** (Baird & Girard). *Flannel-mouth Sucker.*

Very common in the Grand River at Glenwood Springs, in the Gunnison and Uncompahgre at Delta, and in Green River. It reaches a length of 1½ to 2 feet and a weight of 3 to 5 pounds. Dorsal rays usually 11, sometimes 12 or even 13. Caudal peduncle slender, and the fins all high; these characters especially marked in old males. Large specimens, in life blackish, olive above, abruptly paler below; sides bright creamy orange, deepest on the tail; snout and cheeks pale orange; belly pure white; lower fins all more or less orange; upper fins dusky olive, tipped with orange; pectoral dusky, orange above, creamy below; axil blackish; lips very thick and large. Female specimens have the same color, the only difference being that the male has the anal and lower lobe of caudal tuberculate. Stomach full of confervæ and other vegetation.

Catostomus discobolus Cope, from Green River in Wyoming, is probably based on the young of *Catostomus latipinnis.* The fishes from Idaho, formerly recorded by me as *Catostomus discobolus*, are probably different.

2. **Xyrauchen cypho** (Lockington). *Razor-back Sucker; Hump-back Sucker.* (Plate IV, Fig. 11.)

This remarkable fish is very abundant in the river channels of the Colorado Basin. It reaches a weight of 8 to 10 pounds, and is largely used for food. Specimens were taken by us at Delta, both in the Gunnison and the Uncompahgre, and in Green River.

Specimens of 8 inches have the depth equal to length of head, $3\frac{3}{4}$ in length. Scales 13–72, 73, or 74–13; D., 14. First dorsal ray, $1\frac{1}{3}$ in head; base of the fin, $1\frac{1}{7}$. Least depth of caudal peduncle, 3 in head; $1\frac{1}{2}$ in distance from last anal to first caudal ray. Nuchal crest much elevated, commencing by a prominence close to the nape, and with no scales before it; nuchal crest nearly or quite naked on the median line.

3. **Xyrauchen uncompahgre** Jordan & Evermann, sp. nov. (Plate V, Fig. 12.)

A single young specimen of *Xyrauchen*, about 7 inches long, taken in the Uncompahgre River, close to the railway station at Delta, differs much from the others, and probably represents a distinct species of the same singular genus.

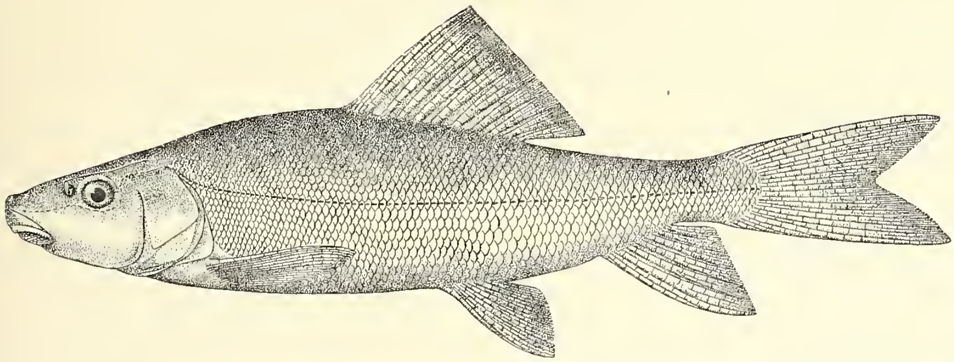


FIG. 12. UNCOMPAHGRE SUCKER (*Xyrauchen uncompahgre*). (See page 26.)

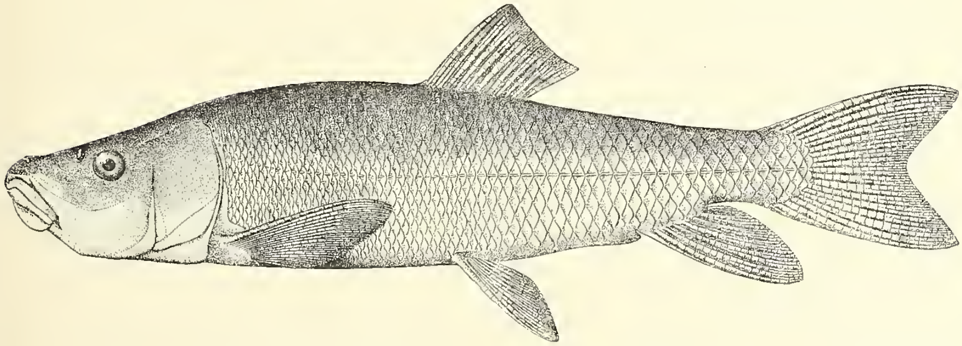


FIG. 13. THE "SUCKER" (*Chasmistes liorus*). (See page 31.)

Head, 4; depth, $4\frac{1}{3}$; D. 12; A. 7. Scales 16–80 to 83–13.

Body more elongate than in *X. cypho* of the same size, the form resembling that of a *Gila;* head flattish above, narrower and less depressed than in *X. cypho*, the snout sharper than in *X. cypho*, projecting considerably beyond the small mouth; lips rather small, but rather larger and more coarsely tuberculate than in *X. cypho*, the upper with three rows of papillæ, the lower deeply incised.

Nuchal hump, formed by the expanded interneurals, much lower than in *X. cypho*, but forming a sharp keel. This does not extend forward to the nape, there being about thirteen scales before it. Surface of nuchal keel scaly.

Eye, $5\frac{1}{2}$ in head; snout, $2\frac{1}{4}$; interorbital space, $2\frac{1}{3}$. Scales smaller than in *X. cypho*, small anteriorly, growing larger backward; breast naked; caudal peduncle slender, much slenderer than in *X. cypho*, its least depth $1\frac{1}{3}$ in its length and $3\frac{2}{5}$ in head. Caudal fin large, deeply forked, a little longer than head. Dorsal lower than in *X. cypho;* the longest ray, $1\frac{1}{5}$ in head; base of fin, $1\frac{1}{4}$. Pectoral, $1\frac{1}{5}$ in head, not reaching ventrals; the latter to vent.

Color bluish above, pale below. Peritoneum black.

Type in the U. S. National Museum.

4. Pantosteus delphinus (Cope). *Blue-head Sucker.*

Common, especially near the mountains. Specimens taken in Eagle River, Gunnison River at Delta, Uncompahgre River, Rio de las Animas Perdidas, and Rio Florida. This species reaches a length of about a foot and is well characterized by its small scales and its large lips. Many die in the rivers after spawning.

In life, bluish, olive, or gray; lower fins dull orange; several round dashes of red along the lateral line, forming an interrupted red band. Scales 96 to 105.

5. Gila robusta (Baird & Girard.) *Round-tail.*

Generally common at the foot of the mountains; replaced by *Gila elegans* in the river channels. Found in the Uncompahgre, and in the Gunnison at Delta.

The species of *Gila* are very similar to each other and are probably reducible to three, *G. elegans*, *G. robusta*, and *G. seminuda*. The last-mentioned I have not seen.

Our specimens from the Gunnison evidently correspond to *Gila robusta*. *Gila grahami* B. & G. seems to be the same. I can not distinguish *Gila affinis* Abbott from *Gila robusta*. This species has been reported from the Kansas and the Platte, but the types doubtless came from Green River, as no recent collectors have found any species of this type anywhere except in the basin of the Colorado and Gila Rivers. *Gila gracilis* B. & G. is not evidently different from *G. robusta*. *Gila nacrea* Cope, from Green River, Wyoming, is evidently the young of *Gila robusta*. Dr. Gilbert has reached independently similar conclusions as to the synonymy of these species.

Gila robusta reaches a length of more than a foot. It is full of small bones and is regarded as worthless for food. The males in life have the lower fins and lower side of the head red, and there is a vertical dash of red on the cheeks. Scales 79 to 82 in the lateral line, those above and below smaller.

6. Gila elegans Baird & Girard. *Bony-tail.*

One specimen taken in the Gunnison at Delta; five in the Green River. Apparently not ascending the streams so far as the preceding.

Comparing specimens of similar size, *Gila elegans* has a higher nape and back, more depressed head, slenderer caudal peduncle, larger fins, and smaller scales on

back and below, although the number in the lateral line is about the same as in *G. robusta*. Scales along middle line of back before dorsal obsolete or nearly so; mouth a little larger than in *Gila robusta*. Least depth of caudal peduncle, $1\frac{3}{5}$ in maxillary ($1\frac{1}{4}$ in *G. robusta*). *Gila emoryi* Baird & Girard seems to be the young of *G. elegans*.

7. **Ptychocheilus lucius** Girard. *White Salmon.*

This species is generally common, specimens having been taken by us in the Gunnison River at Delta, in the Uncompahgre and in Green River. It reaches a weight of 80 pounds or more in the large streams, and is justly regarded as a good food-fish.

The young have always a black caudal spot, the fins are slightly reddish, and there is a slight trace of a pale lateral band below a darker one.

The scales are about 87 instead of 104 as shown in Girard's figure. Maxillary $2\frac{3}{5}$ in head.

8. **Agosia yarrowi** Jordan & Evermann, sp. nov., *Minnow*. (*Apocope oscula* Cope and Yarrow; not *Argyreus osculus* Girard).

This species is very abundant in the small streams in the mountain meadows. In the larger streams it is less common, and in the rivers below the mountains it is rare. Our specimens are from Tomichi Creek, Gunnison River at Gunnison and at Delta, Uncompahgre River, Green River, Eagle River at Gypsum, Rio de las Animas Perdidas, Rio Florida, and Leitner's Creek.

Description from specimens from Tomichi Creek. Head $4\frac{1}{5}$ in length; depth 5 to $5\frac{1}{2}$; D. 7; A. 7; scales 74, 80, 77, 80, 83, 80, 83, 79, 75, 76, 74, 74, 80, 82, in 14 specimens, the average being about 16–80–13. Length from 2 to 5 inches.

Body little compressed, elongate; head long and rather heavy, bluntish; snout short, obtuse, $2\frac{2}{3}$ to $2\frac{3}{4}$ in head; eye small, $5\frac{1}{2}$ to 6; barbel small but distinct. Upper lip, in about half the specimens, separated from the skin of the snout by a fold, as usual in *Agosia* and most other *Cyprinidæ*. In the rest of the typical examples the upper lip is joined mesially to the snout by a distinct frenum. These specimens, although to all appearance specifically identical with the others, would belong to the genus *Rhinichthys*, as now defined. The frenum is, however, considerably narrower than in *Rhinichthys*, and this fact may for the present serve to separate the species from that genus. Lips full; maxillary about $3\frac{1}{2}$ in head; scales small; lateral line complete; dorsal fin well backward, its insertion about midway between base of caudal and eye. Pectoral $1\frac{1}{5}$ in head, usually not quite reaching to ventrals, the latter reaching past vent. Caudal large. Color dark olive, more or less mottled above with black; sides with two ill-defined dark lateral bands, the interspace paler. Axils of fins mostly crimson in life as in related species. This species seems to differ from *A. nubila* and *A. adobe* in its smaller scales, these species having less than 70. Its scales are larger than in *Agosia oscula*.

In the type of *Argyreus osculus*, from Rio Babocomori, in Arizona, there are 90 scales. In the types of *Apocope ventricosa* Cope, from "Arizona and New Mexico," there are 89. We have therefore been compelled to regard our specimen as different from the original *Argyreus osculus*=*ventricosa*.

We have named this species for our friend, Dr. Henry C. Yarrow, in recognition of his work on the fishes of the Rio Colorado.

9. **Salmo mykiss** Walbaum (var. **pleuriticus** Cope).

Trapper's Lake, Eagle River, Cañon Creek, Sweetwater Lakes, Gunnison River, Rio Florida.

Trout are very abundant in all the headwaters of the Colorado and its tributaries wherever the waters are clear and cold. These trout have for the most part the dark spots large and chiefly confined to the posterior part of the body. One specimen from Trapper's Lake is coarsely and closely spotted from head to tail. Others from Eagle River at Gypsum are finely spotted on tail only, repeating the coloration of var. *macdonaldi*, from which they differ mainly in the shorter opercle and the less elongate body.

As a whole, the trout from the Colorado approach most nearly to those from the Rio Grande, but in the specimens counted by me the scales are a little longer in the Rio Grande fish.

Coloration in life of trout from Trapper's Lake, olivaceous; lower fins red, sides with a crimson-red band on level of pectoral, present in every one of eleven specimens. Flesh mostly salmon red. Black spots large, varying much in number, in some much more numerous on the tail; others are closely spotted even to tip of snout. Some with the head spotted, others not. Spots extending low on the sides, usually some on the anal; dorsal and caudal profusely spotted in all.

The trout from Cañon Creek seem to be the young of these; smaller, paler, the spots more confined to the tail. Red markings rather orange than crimson. All show traces of a red lateral band and have the lower fins red. All have much red under the throat and on branchiostegals and opercle. Some of them show round orange blotches on lateral line anteriorly.

Trout from Sweetwater Lake are like those from Trapper's Lake, but with the spots encroaching more on the belly.

Trout from Eagle River show more resemblance to the yellow-fin of Twin Lakes in the small size of the spots and the plain coloration. Their place seems, however, to be in var. *pleuriticus* with the others from the Colorado Basin.

10. Cottus bairdi punctulatus (Gill). Bullhead.

Our specimens correspond with *Uranidea punctulata* Gill, from the head of Green River, except that the dark spots on the body are very irregularly developed and often wanting. They differ from most Eastern examples in the form of the head, which is blunter, lower, and more rounded, and without a distinct medial depression. The black bars usually found in Eastern examples is wanting in these, and in these there are no prickles on the skin behind the axil, nor anywhere else. The specimens found in the headwaters of the Missouri in Yellowstone Park seem to be fully identical with ours from the basin of the Colorado.

Cottus punctulatus may prove to be a species distinct from *C. bairdi* (= *C. richardsoni*, etc.), but some specimens examined by us (Torch Lake, Michigan) seem to be intermediate. Var. *punctulatus* is thus far known from the Upper Missouri and the Upper Colorado. Specimens were obtained by us in Eagle River, Roaring Fork, Gunnison River, at Delta, Rio Florida, Leitner's Creek and Rio de las Animas Perdidas. In the Eagle and Florida it is excessively abundant, as in the streams of the Yellowstone Park.

UTAH.

To the east of the Wahsatch Mountains, Utah is chiefly an arid desert, with little rain-fall, scarcely any vegetation, and no permanent streams of any importance except the Colorado itself. The whole surface is made up of adobe hills and barren mesas,

deeply scored by the erosion of the brief rainy season. Except in the Colorado and in a few brooks and ponds near the crest of the Wahsatch, there are no fishes in eastern Utah. West of the divide of the Wahsatch lies the Great Basin. This is a high, arid plain, largely alkaline, and crossed by numerous short but abrupt mountain chains.

E.—SALT LAKE BASIN.

The lowest part of this basin is occupied by the Great Salt Lake, while other depressions are occupied by other lakes or alkaline sinks, also without outlet. The largest of these in Utah is Sevier Lake. Into these lakes and sinks flow the waters of multitudes of clear streams and springs having their source in the mountains. Most of these streams are well stocked with trout and whitefish in their upper courses. The water farther down is now nearly all consumed by the irrigating ditches of the Mormon settlers, and in Utah, as in Colorado, millions of young trout are each year destroyed by venturing out into these ditches, whence they are scattered over the fields and left to perish. All the valleys of western Utah were formerly covered by the waters of a great post-glacial lake known to geologists as Lake Bonneville. The evidences of the former existence of this lake are everywhere visible in the form of terraces on the sides of the mountains at a considerable height above the present levels of Utah Lake and the Great Salt Lake. Lake Bonneville had probably its outlet to the north through the Snake River. The former connection of the now isolated lakes in the Great Basin must explain the close similarity in the fish faunæ, but we can not tell how close this resemblance is until the fishes of the Great Basin of Nevada, the bed of the former Lake Lahontan, are thoroughly investigated. Collections were made by us at different points in the Salt Lake Basin and in the basin of the Sevier River at Juab.

1. *Utah Lake.*—Utah Lake is about 25 miles long by 10 broad, of irregular form, and surrounded by high mountains. It is shallow near the shore but deep in the middle and in its channels. The surface water is in summer quite warm, while on the bottoms it is very cold. The lake is extremely low in summer, there being but little water running in the outlet. The water is then of a milky blue color and decidedly alkaline. Our collections were made with a long seine, kindly furnished to us by Peter Madsen and his sons, of Provo. This seine was used in a deep channel in the southwestern part of the lake below the mouth of the Spanish Fork. Fishes taken in the lake are marked U in the following list.

2. *Provo River.*—The Provo River is a considerable stream, the largest rising in the Wahsatch range. In the upper course it contains no fishes except trout. Where it leaves the cañon at the foot of the Wahsatch it is very clear and icy cold (temperature about 53°). It flows over a bottom of rounded shingle and small boulders. In and immediately below the cañon it contains only trout and some whitefish. The bottom has no vegetation. Lower down towards the town of Provo the water becomes gradually warmer; the bottom is covered with plants and the banks lined with bushes. The bottom is here of fine gravel and the temperature about 63°. The species taken at this point above the city are marked P in the list. Still lower down the water is all drawn off for irrigation, and only the seepage fills the river bed. Near the mouth of the river, near Madsen's farm, the bottom is of fine gravel, sand, and mud; the water is sluggish and warm (temperature about 78°). The fishes found here are marked M. In Mr. Madsen's carp pond, a muddy pond formed from artesian water, we found *Leuciscus atrarius* and *Hemitremia phlegethontis* very abundant. They had come in

through the overflow of the pond and the chub has proved very mischievous, devouring the eggs and fry of the carp and checking all increase.

3. *Jordan River.*—Jordan River is the outlet of Utah Lake. It is a clear or slightly milky stream, rather warm in summer with moderate current and a bottom of sand and adobe. Chubs, suckers, and sometimes whitefish are everywhere plenty. Trout were common before they were excluded by the dams of the irrigating ditches. These now consume all the water of Jordan River in summer, the river bed being filled up by seepage and by the overflow from the numerous artesian wells. Jordan River was seined at a point just below a dam 4 miles southwest of Salt Lake City. The stream is here about 2 rods wide and 2 to 5 feet deep, the bottom being of adobe; temperature about 63°. Species found in Jordan River are marked J.

4. *Great Salt Lake.*—The waters of the lake are intensely salt and no fishes ever enter them. The only living thing in the water is a small brine shrimp.

FISHES OF THE SALT LAKE BASIN.

1. **Catostomus ardens** Jordan & Gilbert. U., J. "Red Horse Sucker;" "Mullet."

This species is the common sucker of Utah Lake, existing in millions and far outnumbering all the other species combined. The young are very abundant in Jordan River. This species reaches a weight of about 2 pounds. It is very close to *Catostomus teres*, almost the only tangible differences being in the rather smaller scales, the usually longer mandible, 3 to $3\frac{1}{3}$ in head in the adult in *C. ardens*, $3\frac{1}{2}$ to $3\frac{2}{3}$ in *C. teres*, and in the broader upper lip.

Upper lip rather small, with four or five rows of coarse papillæ. Snout forming a moderate "nose;" mandible little oblique or nearly horizontal; scales 63 to 71. Dorsal rays 12 or 13, the fin longer, lower, and less straight on the free edge than in *C. fecundus.* Base of dorsal in adult, $1\frac{1}{3}$ to $1\frac{2}{5}$ in head; longest ray, $1\frac{1}{3}$ to 1 in base of fin; head, 4 in length; eye, small; snout, $2\frac{1}{4}$ in head, pectoral and caudal rather short.

Color of specimens in the lake darker than that of *C. fecundus*, the lower fins dusky. Spawns in March.

2. **Catostomus fecundus** Cope and Yarrow. Webug.

The "Webug" sucker is found only in the lake. It is much less abundant than the preceding, and reaches a smaller size, rarely weighing more than a pound.

It has a small mouth at the end of a long, projecting snout, which forms a distinct nose; mandible very oblique, almost as in *Chasmistes*, its length $2\frac{3}{4}$ to $2\frac{4}{5}$ in head. Snout $2\frac{1}{6}$.

Lips wide but smoothish, the upper with about four rows of large papillæ. Scales 64; D. 11 or 12. Dorsal fin shorter and usually higher than in *C. ardens*, its base in the adult $1\frac{1}{2}$ in head, its longest ray usually a little shorter than the base of the fin. Lower fins long. Color rather pale.

3. **Chasmistes liorus** (Jordan). The "Sucker." U. (Plate V, Fig. 13.)

Abundant in Utah Lake, reaching a weight of 3 pounds. It spawns in June.

Mouth very large, oblique, with full lips, which are non-papillose. A distinct nose; mandible $2\frac{2}{3}$ in head. D. 13. Scales, 66. Fins large. Dorsal low, its free margin a little concave. Longest ray $\frac{5}{6}$ base of fin, which is $1\frac{1}{2}$ in head.

4. **Pantosteus generosus** (Girard). Mountain Sucker. P., J.

Very common in the upper Provo and in the Jordan. Not exceeding 8 inches in

length; the specimens all slender, with short small head, corresponding to *P. platyrhynchus* of Cope.

5. **Rhinichthys dulcis luteus** (Garman). P., J.

Abundant in the Jordan and Provo with the preceding. It is possible that some of the species of *Apocope* of Cope were based on this, which is certainly the commonest species of this type about Provo. Some of the specimens recorded by me as *Apocope vulnerata* (Proc. U. S. Nat. Mus., 1880, 462) belong to it, as I find on re-examination. The Utah fish is almost or quite identical with the ordinary *dulcis*, but the number of scales below the lateral line seems on an average to be slightly greater (usually about 14 above ventrals, while *dulcis* has 11 or 12).

6. **Agosia nubila** (Girard). P.

Rather scarce, and seen only at Provo. These specimens seem to agree fully with those taken in Heart Lake, in the Yellowstone Park. Body robust; head blunt and short; the snout 3 in head, little projecting beyond the mouth. Head $4\frac{1}{5}$ in length; depth, 5. Eye $4\frac{2}{3}$ in head; pectoral rather short, not reaching ventrals. Scales, 72; 65 in two specimens. This species seems to correspond to *Apocope carringtoni, vulnerata* and *rhinichthyoides* of Cope, and the *Apocope henshavii* and *couesi* are not evidently different. The species of this genus are distinguished with great difficulty. The following analysis gives the chief characters which I am able to find. This arrangement is provisional only, and further study may reduce the number of recognizable forms.

a. Scales very small, about 90; snout obtuse, little projecting. Gila River and Lower Colorado Basin. (*notabilis* = *ventricosa*) .... *Oscula.*

aa. Scales small, about 80; snout blunt and heavy, $2\frac{2}{3}$ to $3\frac{2}{3}$ in head; upper lip often joined to the snout by a narrow mesial frenum; eye small. Upper Colorado Basin. (*? oscula* Cope & Yarrow, not Girard) .... *Yarrowi.*

aaa. Scales moderate, 60 to 70.

b. Head short, blunt, and heavy, 4 to $4\frac{1}{4}$ in length; snout short, high, obtuse, $3\frac{1}{4}$ to $3\frac{1}{2}$ in head, its tip scarcely projecting beyond mouth; eye large, about $4\frac{2}{3}$ in head, more than half snout; lateral line broken in the young. Great Basin and Upper Columbia River. (*Carringtoni* = *vulnerata* = *rhinichthyoides* = ? *henshavii* = ?*couesi*) .... *Nubila.*

bb. Head long, $3\frac{2}{3}$ to $3\frac{5}{6}$ in length, with long, rather low, broad snout, pointed in profile, $2\frac{2}{3}$ to $2\frac{5}{6}$ in head; eye small, 5 to 6 in head; little more than half snout, lateral line complete. Sevier River .... *Adobe.*

7. **Leuciscus montanus** (Cope). Silver-side Minnow. P., J.

(*Clinostomus montanus* and *C. tænia* Cope; *?Phoxinus clevelandi* Eigenmann & Eigenmann.)

This is the most abundant fish in the Provo River above the city of Provo. It reaches a length of about 4 inches, and is useful as food for the trout. In form, color, size, and habits, this fish bears a strong analogy to *Notropis coecogenis* of the Alleghany region. I can not separate *L. tænia* from *L. montanus.* The anal rays vary from 10 to 13, the usual number being 10 or 11. Dr. Gilbert has examined the types of both species and finds no difference. *Phoxinus clevelandi* Eigenmann & Eigenmann (West. Amer. Scient., Nov., 1889, 149), from Napa Springs, California, agrees perfectly with *L. montanus*, but the locality is remote. In life, *L. montanus* is greenish blue below the eye; a red band below lateral line, ceasing at front of anal. Dark lateral band almost blue.

8. **Leuciscus copei** Jordan & Gilbert. Leather-side Minnow. P. (*Squalius aliciæ* Jouy.)

Abundant in the Upper Provo. There is no difference between *Squalius copei* from Bear River, a tributary of the Great Salt Lake and *S. aliciæ* described soon after from

Provo River. To this species belongs *Gila egregia* of Cope from Beaver River, but the specimens called *Gila egregia* from the Rio Grande, by Cope & Yarrow, must be some other fish. The type of *Tigoma egregia* Girard has 66 scales. *L. copei* has the scales about 80. It is not unlikely that this species is the original of *Tigoma gracilis* Girard. The types of *Tigoma gracilis* are, however, lost, and the description is too vague to permit identification. The name *gracilis* is also preoccupied in *Leuciscus*. The axils in the males are deep scarlet in *Leuciscus copei*.

9. Leuciscus atrarius (Girard). Chub. M., U., J. (*Siboma atraria* Girard; *Tigoma obesa* Girard; *Tigoma squamata* Gill; *Squalius rhomaleus* Jordan and Gilbert; *Squalius cruoreus* Jordan and Gilbert; ? *Hybopsis bivittatus* Cope; ? *Hybopsis timpanogensis* Cope.)

Excessively common in all waters of the Great Basin except the coldest. It reaches a length of more than a foot, and is very destructive to the young trout, which it captures as they descend the rivers. Reaching a larger size than most of the other chubs, it becomes a food fish of some importance. As the fish grows older, the head becomes proportionately more depressed, and the back more prominent. Such large specimens have become the type of *Squalius rhomaleus*. These large chubs swarm in Utah Lake, and may be taken in the seine, with trout and suckers. Young specimens of the same species were named *Squalius cruoreus*. I have re examined the types of the latter species and find them to be the young of *L. atrarius*. The two species described as *Hybopsis bivittatus* and *H. timpanogensis* Cope are doubtless young chubs, and probably also of this species.

Dr. Gilbert has compared the types of *Tigoma obesa* with those of *Squalius cruoreus* and finds the two identical. The types of *obesus* are bloated by poor alcohol. The name *obesus* is preoccupied by *Leuciscus obesus* Storer.

The species of *Leuciscus* taken by us during the present summer may be thus compared:

a. Scales very small; lateral line 80; body rather elongate, the depth about 4 in length; anal small, with 8 rays; olivaceous, dark-punctate, sides more or less silvery .... *Copei.*
aa. Scales moderate, 52 to 67.
  b. Anal fin rather small, its rays about 8.
    c. Scales rather small, 60 to 67; head rather pointed, the mouth moderate; depth about 4¼ in length .... *Pulcher.*
    cc. Scales larger, 52 to 58.
      d. Scales before dorsal 23 to 28; back becoming elevated with age; dorsal over or rather behind ventrals .... *Atrarius.**
  bb. Anal fin large, its rays 10 to 13; scales 55 to 58; body more or less compressed.
      e. Anal rays usually 10 or 11; snout rather blunt; jaws equal; eye large, about 3 to 3½ in head; depth about 4; sides with a dusky lateral band; sides and belly crimson in the male .... *Montanus.*
      ee. Anal rays usually 12 or 13; its base 6½ in body; snout rather sharp; the lower jaw projecting; eye moderate, 4 to 6 in head in adult; depth 3⅔ to 4 in length; sides with a plumbeous lateral band, with red above and below it in the males. *Hydrophlox.*

* It is not unlikely that *Protoporus domninus* Cope is based on an immature example of this species. The type is from the Snake River at Fort Hall, Idaho. It was 2 inches long, and had the lateral line incomplete.

10. Hemitremia phlegethontis (Cope). M.

Extremely common in the pools of water about the mouth of Provo River and in the carp-ponds. It reaches a very small size, none being seen more than $1\frac{1}{2}$ inches in length.

Head, $3\frac{3}{4}$; depth, $3\frac{1}{3}$. Scales, 36; 17 before dorsal, 11 between dorsal and ventrals. Lateral line obsolete, not a pore being developed. Body short, deep, compressed; head short, compressed, with blunt snout. Mouth short, oblique, the lower jaw projecting; maxillary reaching to front of eye; pectorals about reaching ventrals, the latter to past front of anal.

Color, dark olive; a dark vertebral streak; a dusky streak along side and a very faint caudal spot; scales covered with dark dots. Males in life with fins and sides yellow; axil red; sides of belly dashed with red.

Three of the American species referred to the genus *Phoxinus*, *vittatus* (*flammeus* Jordan & Gilbert), *phlegethontis* and *milnerianus*, differ notably from the European *Phoxinus phoxinus* (L.) in the size of their scales. These are 36 to 45 in these species, while in *Ph. neogæus* the scales are about 80, and *Ph. phoxinus* still smaller.

For these large-scaled species, we may retain the name of *Hemitremia*, originally proposed for *Hemitremia vittata*, by Professor Cope. The name *Hemitremia* was wrongly associated with *Notropis heterodon* and its allies, before the relations of the typical species were understood.

11. Salmo mykiss Walbaum, var. **virginalis** Girard. Trout. P., V. (*Salmo virginalis* Girard; *Salmo utah* Suckley.)

Very abundant in Utah Lake; spawning in the shallow parts of the lake and in the tributary streams which it ascends to the headwaters. The Utah lake trout have the coloration of the Oregon trout, var. *clarki*, but the dark spots are usually somewhat smaller. The only differential character lies in the greater size of the scales, the number of these in a horizontal series being usually about 150.

The large trout of the lakes are deep green in color, the sides silvery, and the dark spots small and faint. Lower fins red. Upper fins yellowish. The usual red dash under the throat is never absent in this species. An excellent account of the habits and economic value of the Utah Lake Trout has been given by Dr. Henry C. Yarrow, (Rept. Lieut. Wheeler, Expl. W. 100th Meridian, V, Zool., pages 685, 693).

No better trout for the table exist than those of the Utah Lake variety. They reach a weight of 3 to 10 pounds. In a single haul of the large seine made in a channel on the south side of the lake, fifty trout ranging from 2 to $3\frac{1}{2}$ pounds were taken. With these were taken six June suckers (*Chasmistes liorus*) weighing about 3 pounds each, two hundred "Mullet" (*Catostomus ardens*) weighing about 2 pounds each, one webug (*Catostomus fecundus*) weighing 1 pound, and about two hundred chubs (*Leuciscus atrarius*), the largest weighing $1\frac{1}{4}$ pounds. This list gives a fair index to the relative abundance of the larger fishes of the lake. The "Sucker," and "Webug" are, however, at times proportionately more abundant.

12. Coregonus williamsoni Girard. P., J. *Mountain Herring* (*White fish.*)

This pretty little fish is common in the Provo River above the city, where it may be readily taken with the hook. It is also occasionally taken in the Jordan. One specimen was procured by us with the seine in the Jordan and several in the colder Provo. It is not a lake fish, being chiefly found in the running waters. Our specimens agree

fully with others from Walla Walla, and differ from those taken in the headwaters of Madison River in the deeper body, longer head, larger scales, and higher fins.

The following gives the measurement of a number of specimens:

Locality.	Head.	Depth.	Scales.	D. longest ray in head.	P. in head.	V. in head.
Jordan River	$4\frac{1}{2}$	$4\frac{5}{6}$	77	$1\frac{1}{4}$	$1\frac{1}{6}$	$1\frac{1}{6}$
Provo River	$4\frac{2}{3}$	$4\frac{1}{2}$	76	$1\frac{1}{3}$	$1\frac{1}{4}$	$1\frac{2}{3}$
Madison River	$4\frac{1}{5}$	5	82–85	$1\frac{2}{5}$	$1\frac{1}{3}$	$1\frac{1}{4}$

13. Cottus bairdi punctulatus Gill. P. (*Uranidea vheeleri* Cope.)

A few specimens, dark in color and much mottled; axil a little rough, otherwise like specimens from the Colorado basin and from Gibbon River.

14. Cottus semiscaber (Cope).

Not rare in the Provo; distinguished from the preceding by its prickly skin; also paler in color, with much black mottling. D. VII, 16. This species is well described by Jordan & Gilbert, Synopsis, p. 695.

FISHES OF THE SEVIER RIVER.

The Sevier River rises in Panquitch Lake, in southern Utah. This lake is in the mountains and is noted for its trout and whitefish. The river, after leaving the mountains, flows northward through a desert country. Its largely alkaline waters are drawn off for irrigation and are reduced by evaporation. It is ultimately lost in a large alkaline pool or sink known as Sevier Lake. In this lake are no fishes.

The Sevier River was seined about the railroad bridge, some 7 miles west of the village of Juab. The river has here a bottom of gravel and firm sand or adobe. It is about 2 rods wide and 1 to 4 feet deep. The water is somewhat muddy, warm (73°), and full of small fishes. It is said that trout (*Salmo mykiss virginalis*) and whitefish (*Coregonus williamsoni*) descend the river in the spring as far as Juab.

In this and similar streams through the Great Basin catfishes might be placed to advantage.

Chicken Lake is a shallow alkaline pond, about a mile long by half a mile broad, between Juab and the Sevier River. It is muddy and full of bulrushes where shallow, and of *Confervæ* and *Myriophyllum* where deep. It is fed by springs. Its outlet is a small brook which flows into the Sevier at the railroad bridge. The waters of Chicken Lake are alive with chubs (*Leuciscus atrarius*) and there are some suckers (*Catostomus*).

1. Pantosteus generosus (Girard).

Very abundant.

2. Catostomus ardens (Jordan and Gilbert).

Abundant, as in Jordan River.

3. Leuciscus montanus (Cope).

Common, very pale, as all fishes are in alkaline waters; no red and no black lateral stripes.

4. Leuciscus atrarius (Girard).

Exceedingly abundant; none seen large.

5. **Leuciscus copei** (Jordan & Gilbert).

Common; axil in male deep scarlet.

6. **Agosia adobe** Jordan and Evermann, sp. nov.

Very abundant in the Sevier River.

The *Agosia* of the Sevier River seems to be certainly distinct from *Agosia nubila* and from all the other species known to me. I am utterly unable to identify it with any of the species described by Cope, nor can I see how most of these species differ from each other or from *A. nubila.* We therefore propose a new name for the Sevier species in allusion to the color of the fish and the bottoms it frequents.

Head $3\frac{2}{3}$ to $3\frac{5}{6}$ in length; depth $4\frac{1}{2}$ to 5. D. 8; A. 7. Scales 12–63 to 70–10. Length of types 2 to 4 inches.

Body rather slender and elongate, formed as in *Rhinichthys.* Head long and low, sharp in profile, the anterior profile forming an even and gentle curve from tip of snout to front of dorsal. Snout sharp, long, more than $\frac{1}{3}$ of head, $2\frac{3}{8}$ to $2\frac{5}{6}$, usually $2\frac{2}{3}$, its tip projecting considerably beyond the thick upper lip. Mouth rather larger than in *A. nubila*, the maxillary extending to behind nostril; barbel well developed. Eye small, about two in snout, 5 to $5\frac{1}{2}$ in head. Lateral line complete. Dorsal inserted midway between front of eye and base of caudal. Pectoral usually shortish and not reaching ventrals, but sometimes passing them. Fins rather high. Caudal well forked, the lower lobe slightly longest.

Color grayish-olivaceous above with a dark lateral band, fins and belly pale; back with some dark dots.

7. **Cottus bairdi punctulatus** (Gill). (*Uranidea wheeleri* Cope.)

Abundant in Sevier River. Color clay-gray, everywhere finely reticulate with olive, the pattern on head very fine. Skin perfectly smooth. These specimens agree fully with others from Gibbon River, except in the shade of the ground color, which in the Sevier corresponds to the bottom of adobe.

UNIVERSITY OF INDIANA, *January* 11, 1890.

INDEX.

Topography taken from map published in 1886, by the U. S. Geological Survey.

2.—A RECONNOISSANCE OF THE STREAMS AND LAKES OF THE YELLOWSTONE NATIONAL PARK, WYOMING, IN THE INTEREST OF THE UNITED STATES FISH COMMISSION.

BY DAVID STARR JORDAN.

[Plates VI to XXII.]

In the summer of 1889, at the instance of Capt. F. A. Boutelle, U. S. Army, acting superintendent of the Yellowstone National Park, a brief visit was made to the Park by Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries. It was made very evident from the observations of the Commissioner that much could be done towards enhancing the attractions of the great national "pleasuring ground" by the stocking of those of its various streams and lakes which are now destitute of fishes.

In September, 1889, the writer was requested by the Commissioner to make a visit to the Park for the purpose of procuring exact data preliminary to the work of introducing trout and other fishes. Dr. Charles H. Gilbert was asked to assist in this work.

The memorandum of instruction ran as follows:

"A considerable portion of Yellowstone Park is a volcanic plateau, in which have been excavated the lakes Yellowstone, Shoshone and Lewis, and a number of smaller lakes. The drainage from this region reaches the headwaters of the Snake and Missouri Rivers by falls impassable to fish, most of which are within the limits of the Park, and some beyond the limits. The waters above these falls (the aggregate basins embracing an area of some 1,500 square miles), so far as my observation extends, are entirely barren of fish except Yellowstone Lake and its tributaries, in which the black-spotted trout, *Salmo purpuratus* [*Salmo mykiss*], is very abundant. I have proposed to undertake to stock these waters with different species of *Salmonidæ*, reserving a distinct river basin for each.

"It is important to settle in advance what I believe to be the fact, that there is now an entire absence of fish fauna in the region above the falls, except Yellowstone Lake, and to determine precisely and fully the species to be found in the waters draining from the Park and below the impassable obstruction. It is also desirable to get information in regard to the parasitic flesh-worm which is so common in the Yellowstone trout, and to receive suggestions as to the study of this parasitic worm.

"The waters proposed to be stocked should also be examined with reference to the abundance of other forms of aquatic life which might serve as food for the fishes, both the fry and the adult. Special study in this regard should be made of the waters of

Lakes Shoshone and Lewis, which it is proposed to stock with the land-locked salmon and Loch Leven trout.

"Capt. F. A. Boutelle, U. S. Army, acting superintendent of the Park, will be notified by telegraph of your proposed exploration, and requested to give you every facility for it."

Other engagements rendered it impossible for us to start before September 24, 1889, a late date for such work, as the climate of the Park is subarctic, and serious snow-storms may be expected at any time after the middle of September. We were very fortunate, however, as we arrived in the Park just after a storm, and throughout our stay Indian-summer weather prevailed and no time was lost on account of snow.

The following is the itinerary of the trip:

September 24.—Left Bloomington, Ind., in company with Dr. Charles H. Gilbert and Mr. William W. Spangler, librarian of the Indiana University, volunteer assistant.

September 27.—Arrived at the Mammoth Hot Springs.

September 28.—Examined Gardiner River, above and below the Osprey Falls; also visited Obsidian and Glen Creeks.

September 30.—Seined Gardiner River about the mouth of Hot River.

October 1.—Started with tents, pack-horses, etc., on a tour of the Park, accompanied by Elwood Hofer, guide; David Rhodes and John Innes, packers; and Richard Randall, cook. Visited Lava Creek and its falls, and Black-tail Deer Creek. Encamped at night at Yancey's on Elk Creek.

October 2.—Visited Tower Creek and Antelope Creek, crossed Mount Washburn and encamped at its base on the south side.

October 3.—Ascended the Yellowstone River and encamped on its banks about 1½ miles south of the Giant's Cauldron.

October 4.—Encamped on Yellowstone Lake, on the north shore of the western arm or "Thumb."

October 5.—Passed around the "Thumb" of the Lake; ascended Solution Creek, and encamped on Riddle Lake.

October 6.—Crossed the Divide to Heart Lake; examined Witch Creek.

October 7.—Went from Heart Lake across the base of Red Mountain; passed Lewis Lake to Shoshone Lake; encamped at the mouth of Heron Creek.

October 8.—Went from Shoshone Lake across the Divide to Firehole River; encamped at the Upper Geyser Basin.

October 9.—Went down the Firehole River to its falls; encamped on Cañon Creek.

October 10.—Examined Gibbon River, Twin Lakes, Obsidian Creek, etc. Reached Mammoth Hot Springs in the evening.

October 11.—Received fishes from Horsethief Spring, obtained by Mr. E. R. Lucas. Left Mammoth Hot Springs.

October 15.—Reached Bloomington, Ind.

Our trip was necessarily considerably hurried, though long enough to enable us to make out the leading points of the problems in question. A more complete survey of the Park and the surrounding region would enable us to work out in detail the distribution of the fishes found lower down the streams. The distribution of the Miller's Thumb or Blob (*Cottus bairdi punctulatus*) needs special study. The distribution and conditions of life of the parasitic worm (*Dibothrium cordiceps* Leidy), found in the trout of Yellowstone Lake, as well as those of the larger worm found in the sucker of Witch Creek, will demand a whole summer's attention from some one familiar with the subject.

In all our work we had the cordial and intelligent co-operation of Capt. F. A. Boutelle, acting superintendent of the Park, of Lieut. W. E. Craighill, of the U. S. Engineer Corps, and of Lieutenant Edwards, U. S. Army. We were fortunate in securing

PLATE VII.

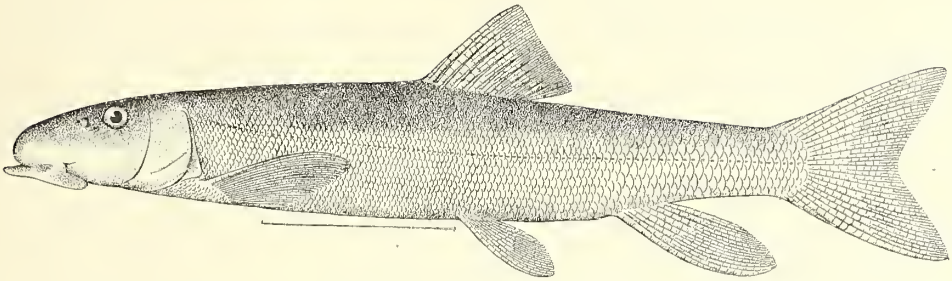


FIG. 1. GRAY SUCKER (*Catostomus griseus*). (See page 46.)

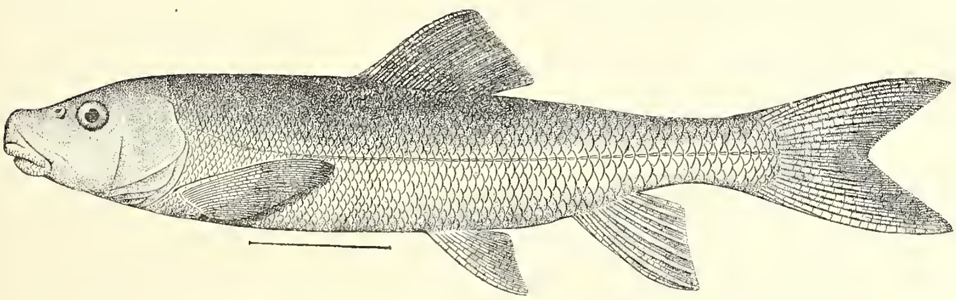


FIG. 2. RED HORSE SUCKER (*Catostomus ardens*). (See page 47.)

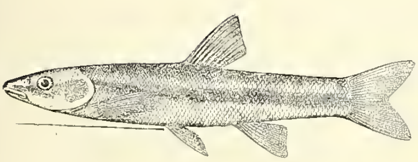


FIG. 3. THE DACE (*Rhinichthys dulcis*). (See page 48.)

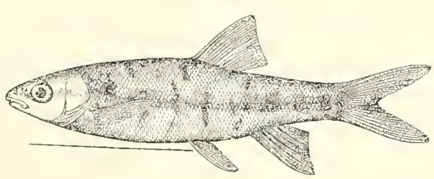


FIG. 4. (*Agosia nubila*). (See page 48.

the services, as guide, of Mr. Elwood Hofer, to whom we are indebted for much valuable help. Mr. E. R. Lucas, of the distributing division of the U. S. Fish Commission, also aided us materially by collecting specimens from tributaries of Madison River and Henry River. Mr. Arnold Hague, of the U. S. Geological Survey, also gave us considerable valuable information.

The following is a classified list of the waters examined, those lakes and streams containing trout being printed in italics:

Yellowstone Basin:

- *Yellowstone River.*
- *Yellowstone Lake* (altitude, 7,741 feet).
- *Riddle Lake* (altitude, 7,900 feet).
- *Solution Creek.*
- Bridge Bay Creek.
- Arnica Creek.
- *Trout Creek.*
- *Alum Creek.*
- Cascade Creek.
- Sulphur Creek.
- *Antelope Creek.*
- Tower Creek.
- Lost Creek.
- Elk Creek.
- Oxbow Creek.
- Geode Creek.
- *Black-tail Deer Creek.*
- *Lava Creek.*
- *Lupine Creek.*
- *Gardiner River.*
- Twin Lakes.
- Obsidian Creek.
- Beaver Lake.

Yellowstone Basin—Continued:

- Winter Creek.
- Indian Creek.
- Glen Creek.

Madison Basin:

- *Madison River.*
- Firehole River.
- Iron Spring Creek.
- Little Firehole Creek.
- Goose Lake.
- Nez Percé River.
- *Gibbon River.*
- *Cañon Creek.*
- *Horsethief Spring.*

Snake River Basin:

- Shoshone Lake (altitude, 7,740 feet).
- Heron Creek.
- Lewis Fork.
- Lewis Lake (altitude, 7,720 feet).
- *Heart Lake* (altitude, 7,469 feet).
- *Witch Creek.*
- Howard's Creek.
- Henry's Lake.

The Yellowstone Park is a high plateau, having a general elevation of 7,000 to 8,000 feet above the sea. Its entire surface, with the exception of the Gallatin range of mountains in the northwest, and some granitic summits in the northeast, is covered with lava, with its varieties of obsidian, rhyolite, etc. This mass of lava covers to a great depth what was previously a basin in the mountains. According to Mr. Hague, the date of the lava flow is probably Pliocene. Its existence was of course fatal to all fish life in this region. Since its surface has become cold, the streams flowing over it, most of them now wholly unaffected by the heat within, have become well stocked with vegetable, insect, and crustacean life, but are for the most part destitute of fishes. The cause of this absence of fishes is to be found in the fact that nearly all the streams of the Park on leaving the lava beds do so by means of vertical water-falls situated in deep cañons. Except in the Yellowstone and its tributaries, in Gibbon River and in Lava Creek, no fishes have been found above these falls, and the presence of fishes in the Upper Yellowstone and Lava Creek is doubtless due to the imperfect character of the water-sheds separating these streams from others.

The following is a list of the water-falls in the Park, supposed to be unsurmount

able by trout. No account is here taken of the numerous falls in small brooks or in mountain torrents unsuited to fish life:

Great Falls of the Yellowstone, 308 feet high.
Upper Falls of the Yellowstone, 109 feet high.
Crystal Falls in Cascade Creek, 129 feet high.
Tower Falls in Tower Creek, 132 feet high.
Undine Falls in Lava Creek, 60 feet high.
Lower Falls in Lava Creek, 50 feet high.
Wraith Falls in Lupine Creek, 100 feet high.
Falls in Slough Creek.
Osprey Falls in Gardiner River, 150 feet high.
Rustic Falls in Glen Creek, 70 feet high.
Virginia Cascades in Gibbon River, 60 feet high.
Gibbon Falls in Gibbon River, 80 feet high.
Keppler's Cascade in Firehole River, 80 feet high.
Firehole Falls in Firehole River, 60 feet high.
Falls in Lewis River, 80 and 50 feet high.
Moose Falls on Crawfish Creek.
Union Falls on Mountain Ash Creek.
Terraced Falls and Rainbow Falls on Falls River.
Iris Falls and Colonnade Falls on Bechler River.

Outside the Park the falls in Clarke's Fork of the Yellowstone exclude fish from that river, and perhaps the great Shoshone and American Falls in Snake River exclude from the upper part of the stream the fauna of the Lower Columbia. Another supposed obstacle to the spread of fish life in the Yellowstone Park is the presence of the innumerable hot springs, solfataras, and geysers, for which the region is famous. Although these springs exist in almost every lake basin, cañon, or other depression in the Park, we do not think that in their present condition, at least, they would stand in the way of the stocking of the streams and lakes with fishes.

The water of the geysers and other calcareous and silicious springs does not appear to be objectionable to fishes. In Yellowstone Lake trout are especially abundant about the hot overflow from the Lake Geyser Basin. The hot water flows for a time on the surface, and trout may be taken immediately under these currents. Trout have also been known to rise to a fly through a scalding hot surface current. They also linger in the neighborhood of hot springs in the bottom of the lake. This is probably owing to the abundance of food in these warm waters, but the fact is evident that geyser water does not kill trout.

In Heart Lake trout were found most plentiful about the mouth of the Warm Witch Creek. Suckers and chubs (*Leuciscus atrarius*) ascend this creek for some distance, although half its water comes from geysers and hot springs. The chubs are found in water in which the temperature is about 85° Fahr.

The Hot River, which drains the Mammoth Hot Springs, flows into Gardiner River. Trout abound about the mouth of this stream, and here, as in numerous other places in the Park, the conventional trick of catching a trout in cold and scalding it in hot water is possible. Below the mouth of this Hot River young suckers (*Catostomus griseus*) were found in a temperature of about 88°, and young trout in a temperature of about 75°.

Miller's Thumbs abound in the Gibbon River, about the hot springs. Three were found boiled in the edge of the river below Elk Park, at the mouth of a hot tributary. The volume of hot water poured into any river is greatest in the Firehole, below the upper Geyser Basin. The stream, however, is hardly warm, and the water has little mineral taste, though the abundant vegetation gives it something of the flavor of stewed plants. Even this stream, it would seem, is probably not so hot nor so heavily charged with mineral substance as to be unfit for trout. Its waters constitute a very dilute alkaline silicious solution. The following analysis of the waters of Firehole River is given by Gooch and Whitfield:*

* Bull. U. S. Geol. Survey, No. 47, page 57.

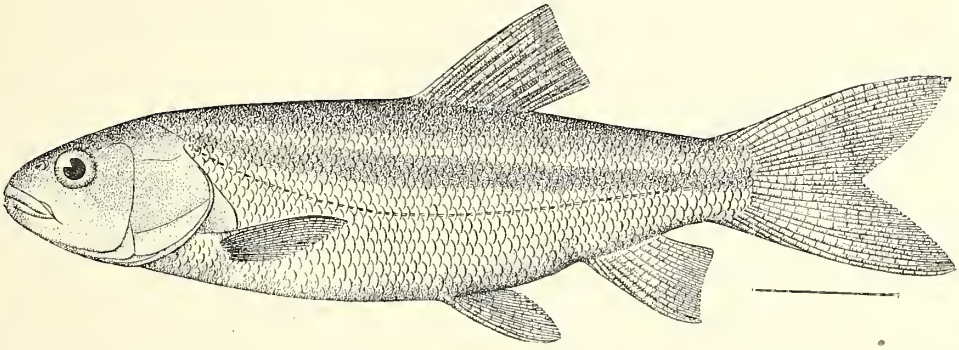


FIG. 5. THE UTAH CHUB (*Leuciscus atrarius*). (See page 48.)

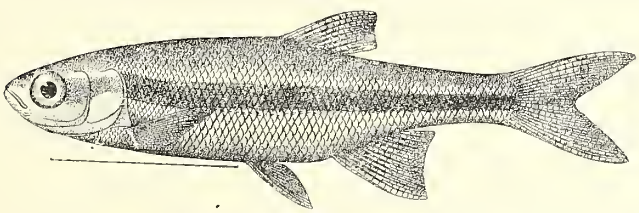


FIG. 6. (*Leuciscus hydrophlox*). (See page 48.)

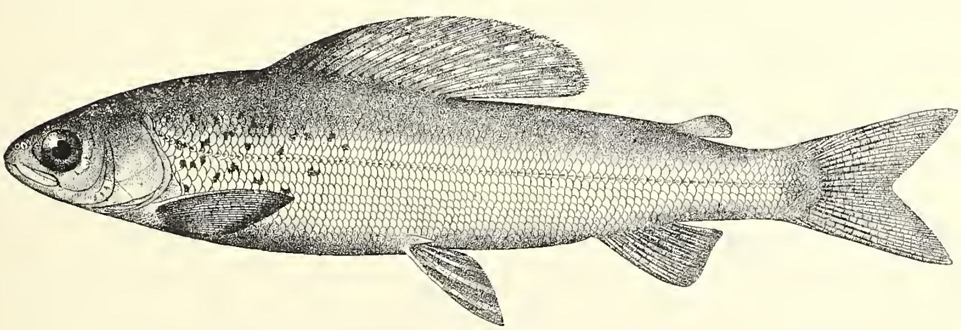


FIG. 7. THE GRAYLING (*Thymallus signifer*, var. *ontariensis*). (See page 49.)

[The sample was taken from above the mouth of Nez Percé River August 24, 1884; temperature 8° C; reaction, alkaline; specific gravity, 1.00031.]

[Hypothetical combination.]

Constituents.	Grams per kilogram of water.	Per cent. of total material in solution.	Constituents.	Grams per kilogram of water.	Per cent. of total material in solution.
Na_2CO_3	0.1201	27.51	$Na_2B_4O_7$	0.0087	1.99
SiO_2	0.0965	22.10	$LiCl$	0.0067	1.53
$NaCl$	0.0867	19.86	Al_2O_3	0.0059	1.35
CO_2	0.0457	10.47	$MgCO_3$	0.0024	0.55
KCl	0.0325	7.44			
$CaCO_3$	0.0165	3.78		0.4366	100.00
Na_2SO_4	0.0149	3.42			

This analysis may be compared with that given by the same authors for the Gardiner River above and below the mouth of Hot River, in both of which localities trout are abundant.

[Gardiner River above Hot River, October 12, 1883; temperature 8° C.]

[Hypothetical combination.]

Constituents.	Grams per kilogram H_2O.	Per cent. of material in solution	Constituents.	Grams per kilogram H_2O.	Per cent. of material in solution.
$CaCO_3$	0.0625	29.25	Al_2O_3	0.0079	3.70
SiO_2	0.0469	21.95	K_2SO_4	0.0056	2.62
Na_2CO_3	0.0340	15.91	$MgCO_3$	0.0018	0.84
CO_2	0.0286	13.38	$LiCl$	trace	....
Na_2SO_4	0.0161	7.53			
KCl	0.0103	4.82		0.2137	100.00

[Gardiner River below Hot River, September 26, 1884; temperature, 13° C.]

Constituents.	Grams per kilogram H_2O.	Per cent. of material in solution.	Constituents.	Grams per kilogram H_2O.	Per cent. of material in solution.
$CaCO_3$	0.1873	37.94	KCl	0.0200	4.00
CO_2	0.0852	17.26	$MgCO_3$	0.0094	1.95
$MgSO_4$	0.0739	14.97	Al_2O_3	0.0019	0.38
Na_2SO_4	0.0549	11.12	$LiCl$	trace	....
$NaCl$	0.0339	6.87			
SiO_2	0.0272	5.51		0.4937	100.00

There are, however, numerous springs in the park which discharge sulphurous liquids (some of them the black ammonic sulphide $(NH_4)_2S$, very offensive in odor and doubtless fatal to fishes. Most of these springs have but a very slight discharge, and so exert no appreciable influence on the streams. The upper part of Obsidian Creek between Twin Lakes and Beaver Lake is the only running stream noticed by us as likely to prove uninhabitable by fishes. An obstacle of equal importance in the lower course of the same creek is the series of three beaver-dams, to which the existence of Beaver Lake is due; these, with their covering of brush, must be wholly impassable.

The following is a list of the species of fishes found by us in the park, with a list of the localities from which specimens of each were actually obtained:

Catostomidæ (Suckers).

1. *Catostomus griseus* (Girard). Gardiner River (below Mammoth Hot Springs).
2. *Catostomus ardens* Jordan & Gilbert. Witch Creek; Heart Lake.

Cyprinidæ (Minnows, Chubs, etc).

3. *Rhinichthys dulcis* (Girard). Gardiner River (below Mammoth Hot Springs).
4. *Agosia nubila* (Girard). Witch Creek; Heart Lake.
5. *Leuciscus atrarius* (Girard). Witch Creek.
6. *Leuciscus hydrophlox* (Cope). Heart Lake; Witch Creek.

Thymallidæ (Grayling).

7. *Thymallus signifer* Richardson. Horse-thief Spring; Madison River; Gallatin River.*

Salmonidæ (Trout, etc.).

8. *Coregonus williamsoni* Girard, var. *cismontanus* Jordan. Horse thief Spring; Madison River, Gardiner River (below falls); Yellowstone River (below the falls).
9. *Salmo mykiss* Walbaum. The "Red-throated," *Cut-throat*, or "Rocky Mountain Trout." Heart Lake; Henry Lake; Howard Creek; Yellowstone Lake; Yellowstone River (above falls); Yellowstone River (at Livingston); Gardiner River (below falls); Black-tail Deer Creek; Alum Creek; Solution Creek; Riddle Lake; Cañon Creek; Madison River.
10. *Cottus bairdi* Girard, (var. *punctulatus* Gill); Gibbon River (above falls); Cañon Creek; Horse-thief Spring.

In August and September, 1889, plants of fishes were made by the U. S. Fish Commission as follows:

Eastern Brook Trout (*Salvelinus fontinalis*), in Glen Creek and in Gardiner River above the falls (5,000 fishes).

Rainbow Trout (*Salmo irideus*), in Gibbon River, above Virginia Cascades, (1,000 fishes).

Loch Leven Trout (*Salmo trutta levenensis*) in Firehole River above Keppler's Cascades (1,000 fishes).

Mountain Whitefish (*Coregonus williamsoni*). One thousand fishes in each of the Twin Lakes and in Yellowstone River below the lake.

Red-throat Trout (*Salmo mykiss*), in Lava Creek above the falls.

THE FISHES OF THE PARK.

The following notes are those made by us on the species of fishes collected in the Park:

1. Catostomus griseus Girard. (*Acomus lactarius* Girard; *Catostomus retropinnis* Jordan.) (Plate VII, Fig. 1.)

This sucker is abundant in the Yellowstone and Gardiner Rivers below the falls, and numerous young specimens were taken by us in Gardiner River near the bridge below the mouth of the Hot River. No large examples were seen, but the species is said to reach a length of 18 inches.

These specimens apparently belong to the form described by Girard from the Milk River, Montana, under the name of *Acomus lactarius*. This is probably a slight variety, or perhaps it is identical with the species found in the Platte Valley, and described by Girard under the name of *Acomus griseus*. It is probable that *Catostomus retropinnis* Jordan (from the Milk River and the Platte) was based on adult specimens of *Catostomus griseus*, a species very close to *Catostomus catostomus*.

* Specimens not seen by us.

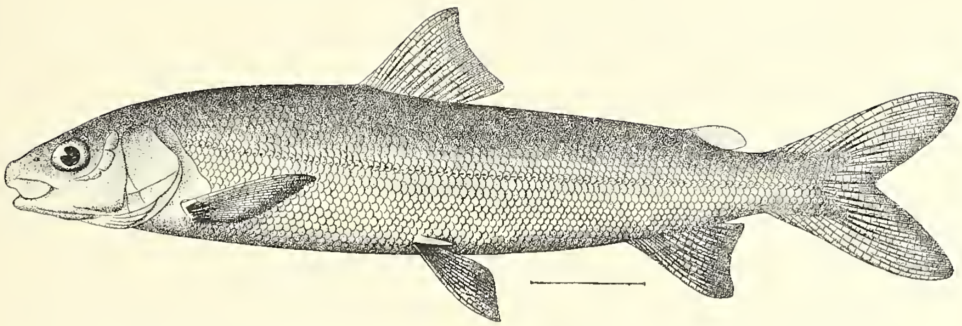


FIG. 8. MOUNTAIN WHITEFISH (*Coregonus williamsoni*, var. *cismontanus*). (See page 49.)

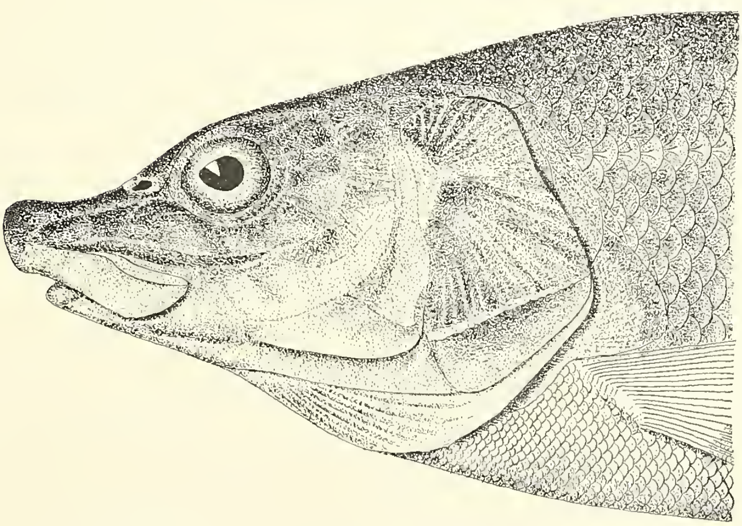


FIG. 9. MOUNTAIN WHITEFISH (*Coregonus williamsoni*, var. *cismontanus*).
(Head of breeding male.) (See page 49.)

Compared with the young of *C. catostomus* (from Keweenaw Bay), *C. griseus* has the upper lip much thicker, with 5 or 6 instead of about 3 rows of tubercles. The lower lip is much larger in *C. griseus*, and the lower jaw has a rather distinct cutting edge. The head is larger, and the eye larger in *griseus*, and the scales on the posterior part of the body are less reduced in size. I am not sure, however, of the permanent value of any of these characters. The specimens from Gardiner River have the scales 88 to 90, while in more typical examples of *C. griseus* (from the South Platte River at Hartsell's Hot Springs and at Denver) the scales are 105 to 110. Should the difference prove constant, the specimens from the Upper Missouri region should stand as a separate variety of *Catostomus griseus lactarius*. It is not at all likely that these characters can be depended upon.

Dorsal rays 10 or 12; fontanelle well developed; color, dark gray, irregularly mottled and barred with black.

2. **Catostomus ardens** Jordan & Gilbert. (Plate VII, Fig. 2.)

Head $3\frac{5}{6}$ to 4 in length; depth, $4\frac{1}{4}$ to $4\frac{1}{2}$; D. 2.11 to 2.13; A 7. Scales 12–70 to 72–12. Length of types, 6 to 8 inches.*

Body moderately elongate, not strongly compressed; head broad, acutely conical, the snout short and sharp, $2\frac{1}{3}$ to $2\frac{1}{2}$ in head. A depression behind tip of snout, so that it forms a distinct projecting nose. Eye small, $5\frac{1}{2}$ in head. Lower jaw rather strong, obliquely placed, $2\frac{4}{5}$ in head. Mouth small, the lips full, the upper thick, with about 6 rows of rather coarse papillæ; lower with many rows of papillæ which are coarser in front, the lip deeply bifid: lower jaw without evident cartilaginous sheath. Interorbital space broad, $2\frac{3}{4}$ in head. Fontanelle well developed. Scales small, crowded anteriorly, about 32 before dorsal. Fins moderate; dorsal with its free margin nearly straight, its longest rays reaching when depressed somewhat beyond the middle of the last rays, their length $1\frac{2}{5}$ in head. Caudal moderate, well forked, the upper lobe the longer, the peduncle moderate. Pectorals long, $1\frac{1}{8}$ in head. Ventrals and anal moderate.

Color grayish-olive above, paler below; no distinct markings; the young vaguely barred with dark olive. Very abundant in the warm waters of Witch Creek, the young also abundant in Heart Lake. The largest taken are about 8 inches in length.

This species seems to be indistinguishable from the common sucker of Utah, *Catostomus ardens*, and is quite unlike the *Catostomus macrocheilus* of the Lower Columbia. This fact, together with the general affinity of the fishes of Heart Lake with those of the Great Basin, suggests that the fauna of the Upper Snake River, above the great Shoshone Falls, may have been derived from the Great Basin rather than from the Lower Columbia. The effect of the Shoshone Falls as a barrier to the distribution of fishes is worthy of a careful investigation.

About one specimen in every three or four of *Catostomus ardens* was found to contain a long, flat, intestinal worm of unusual size, so large as much to distend the walls of the abdomen. Some of these worms were more than a foot in length, and greater than the whole abdominal viscera of the fish. The worm is apparently loose in the abdominal cavity, and can be found in every case by making an incision along the median line of the belly. The infected individuals did not appear poor or dis-

* A much larger example, some 16 inches long, has since been sent us by Dr. S. A. Forbes. It was taken with a trammel net in Heart Lake in July, 1890. The lips seem a little fuller in the Heart Lake fishes as compared with those from Utah.

eased. These and other worms taken by us in fishes of the Park are the subject of a special report by Prof. Edwin Linton.

3. Rhinichthys dulcis (Girard.) (Plate VII, Fig. 3.)

This species is common in nearly all cold clear streams in the Rocky Mountains. It is rather abundant in the Gardiner River below the falls, and it might probably be introduced to advantage in the rivers above the falls as food for trout. Our specimens agree with all others examined by us from both slopes of the Rocky Mountains in having the barbel very small and the insertion of the dorsal a little farther back than in the Eastern species, *Rhinichthys cataractæ*, midway between nostril and base of caudal. In *R. cataractæ* the insertion of the dorsal is about midway between tip of snout and base of caudal. The western form may stand as *Rhinichthys dulcis* (=*Argyreus dulcis* Girard=*Rhinichthys maxillosus* Cope=*Rhinichthys transmontanus* Cope=*Rhinichthys luteus* Garman=*Rhinichthys ocella* Garman.)

Rhinichthys dulcis is an active little minnow, abounding about cascades and in swift brooks. It reaches a length of about 5 inches.

4. Agosia nubila (Girard). (Plate VII, Fig. 4.)

A little fish inhabiting brooks and swift waters, agreeing very closely in appearance and habits with *Rhinichthys dulcis*. It is as abundant in the Columbia basin as the other is on the eastern side. It extends its range southward to Utah, and perhaps beyond. We found this species rather common in the warm waters of Witch Creek. Scales 63 to 65; lateral line complete.

5. Leuciscus atrarius Girard, (Plate VIII, Fig. 5.)

I identify with Girard's *Siboma atraria* a chub which is abundant in Heart Lake and which ascends its warm tributary—Witch Creek—in great numbers, going up farther than any other fish (temperature 88°). It reaches a length of about 7 inches.* *Cheonda cœrulea*, known from a single specimen from Lost River, Oregon, may be the same also. The Witch Creek fish is less slender than Girard's type, but the probabilities are that the two are identical.

The Witch Creek fish seems to belong to the same species as the common chub of Utah (*Leuciscus atrarius*). It is a rather slenderer fish than the latter, with heavier head, lower back, and more slender tail; scales a little smaller, 11–56–6; 28 to 30 before dorsal (23 to 28 in *atrarius*). In form of mouth, eye, fins, and coloration there is no evident difference. Color dusky olive; the scales everywhere with dark points. Head 4 in length; depth $3\frac{4}{5}$; teeth 2, 5, 4, 2, with rather broad grinding surface. Mouth oblique, the maxillary just reaching eye; lateral line much decurved; dorsal inserted behind ventrals; pectorals short, not nearly reaching ventrals.

The females of this species were full of eggs at the time of our visit. No worms were found in this species.

6. Leuciscus hydrophlox (Cope). (Plate VIII, Fig. 6.)

A few specimens, the largest about 4 inches long, were taken in Heart Lake and in Witch Creek. This species was previously known from Blackfoot Creek, Idaho,

* A specimen over a foot long and entirely similar to the large chubs of Utah Lake has been lately sent us by Dr. S. A. Forbes. It was taken with a trammel net in Heart Lake in July, 1890.

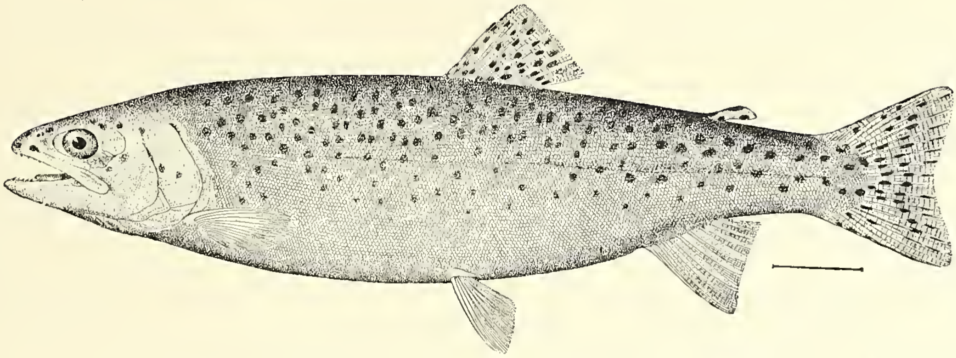


FIG. 10. RED-THROATED TROUT (*Salmo mykiss*). (See page 50.)

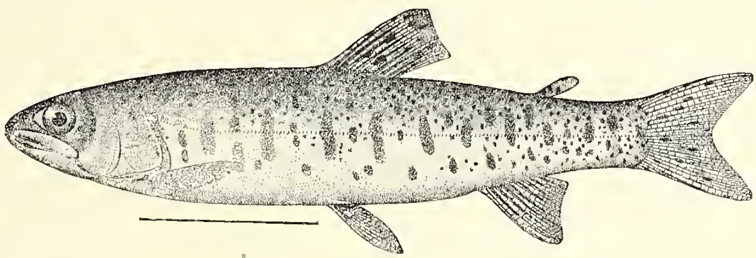


FIG. 11. RED-THROATED TROUT (*Salmo mykiss*). Young. (See page 50.)

FIG. 12. MILLER'S THUMB (*Cottus bairdi*, var. *punctulatus*). (See page 53.)

which flows into the Snake River lower down. This species is allied to *Leuciscus montanus* (= *Clinostomus tænia*) Cope, differing chiefly in the longer anal, sharper snout, and smaller eye. In technical characters it has much in common with *Richardsonius lateralis*, which suggests that *Richardsonius* may be a near ally of the *Clinostomus* group of the genus called *Leuciscus*.

Head, 4¼ in length; depth, 3¼ to 4. Anal 2, 13; lat. l. 55. Color silvery, a plumbeous lateral band, dusted with dark points; traces of red coloration on belly in largest specimen. Lateral line much decurved. Pectoral and ventral fins long and falcate. Base of anal 6½ in body; lower jaw slightly projecting; upper jaw less blunt and decurved than in *L. montanus*. Eye as long as snout; 3½ in head (young).

7. **Coregonus williamsoni** Girard (var. *cismontanus.*) (Plate IX, Figs. 8 and 9.)

The mountain whitefish is abundant in the Madison River below the falls. It is said to be equally common in the Yellowstone River, but none were obtained by us. It is a slender and graceful fish, readily taking the fly like a grayling or trout. It is most abundant, so far as we have noticed, in the eddies or deeper places in swift streams. It seems to be essentially a river fish, rather than an inhabitant of lakes.

Comparing our specimens from Horsethief Creek, a tributary of Madison River, with others collected at Walla Walla (Washington, Captain Bendire), these specimens from the Missouri seem notably different, the body being much more slender and the fins shorter. In coloration, and in the form of the head, mouth, and eye, there is substantial agreement.

In the Madison River specimens, the depth is 5 to 5¼ in the length, the head 5, the pectoral, 1½ in head, the ventral 1⅘, the longest dorsal ray, 1½, the scales, 90. In the Walla Walla fishes, the depth is 4½ to 4¾, the head 4⅗, the pectoral 1⅕, the ventral 1⅖, the dorsal 1⅓, the scales 83. Specimens from the Willamette River at Salem, Oregon, and others from Jordan River and Provo River in Utah, agree in these respects with the specimens from Walla Walla.

If these differences should prove at all constant, the Missouri River whitefish should stand as a distinct variety, *Coregonus williamsoni cismontanus*. The type of *Coregonus couesi* Milner, is from Chief Mountain Lake, Montana, a tributary to the Saskatchawan on the east side of the Divide. This specimen, lately examined by me, shows the prolonged snout characteristic of the males in the breeding season. In all respects, so far as I can see, it agrees with the typical form of *Coregonus williamsoni* and not with the variety found in the Park. Its scales are 84; the pectoral is 1⅕ in the head, 5½ in the body; the ventrals are 1⅓ in head. The depth 4½ in length; the dorsal is broken. *C. williamsoni* much resembles *C. quadrilateralis*, but the latter has a smaller mouth and the gill-rakers notably shorter and thicker.

8. **Thymallus signifer** Richardson. (Var. *ontariensis.*) (Plate VIII, Fig. 7.)

The Grayling is very abundant in the Madison River below the junction of the Firehole and the Gibbon. Numerous specimens were collected for us in Horse Thief Spring, a small stream just outside the limits of the Park, by Mr. Lucas. The grayling is said to ascend the river in summer as far as the Firehole Falls and Gibbon Falls. It is said also to be found in the Gallatin River, in the northwestern part of the Park.

We have carefully compared our specimens with others collected by Judge D. D. Banta, in Otter Creek, in the Keweenaw Peninsula, and with a specimen from Au Sable

River, in the southern peninsula of Michigan. The first-named locality, by the way, is one not generally known and not previously recorded. The occurrence of Grayling in the northern peninsula of Michigan is even disputed by anglers.

The differences noted by Mr. Milner as distinguishing the Montana fish (as *Thymallus montanus* Milner) do not seem to be constant. The Montana specimens are not deeper than the others (depth 5¼), and in the number of the scales (98) they agree with the Otter Creek specimens. The Au Sable specimen has 93 scales. The dorsal rays are 21 or 22 in Michigan specimens, 19 in those from Montana. The only differences evident are in the color of the dorsal fin. This is alike in all the Montana specimens, but its peculiarities may be due to difference of season. In the Montana examples (in alcohol) the fin is largely dusky green. Its posterior part has three or four rows of bright orange-brown spots, faintly ocellated, irregular in position, some of the spots oblong and obliquely placed. Above this is one regular row of similar spots, extending obliquely across the fin from the end of the second third of the anterior rays to the tip of the last ray. Fin edged above with the same bright orange-brown.

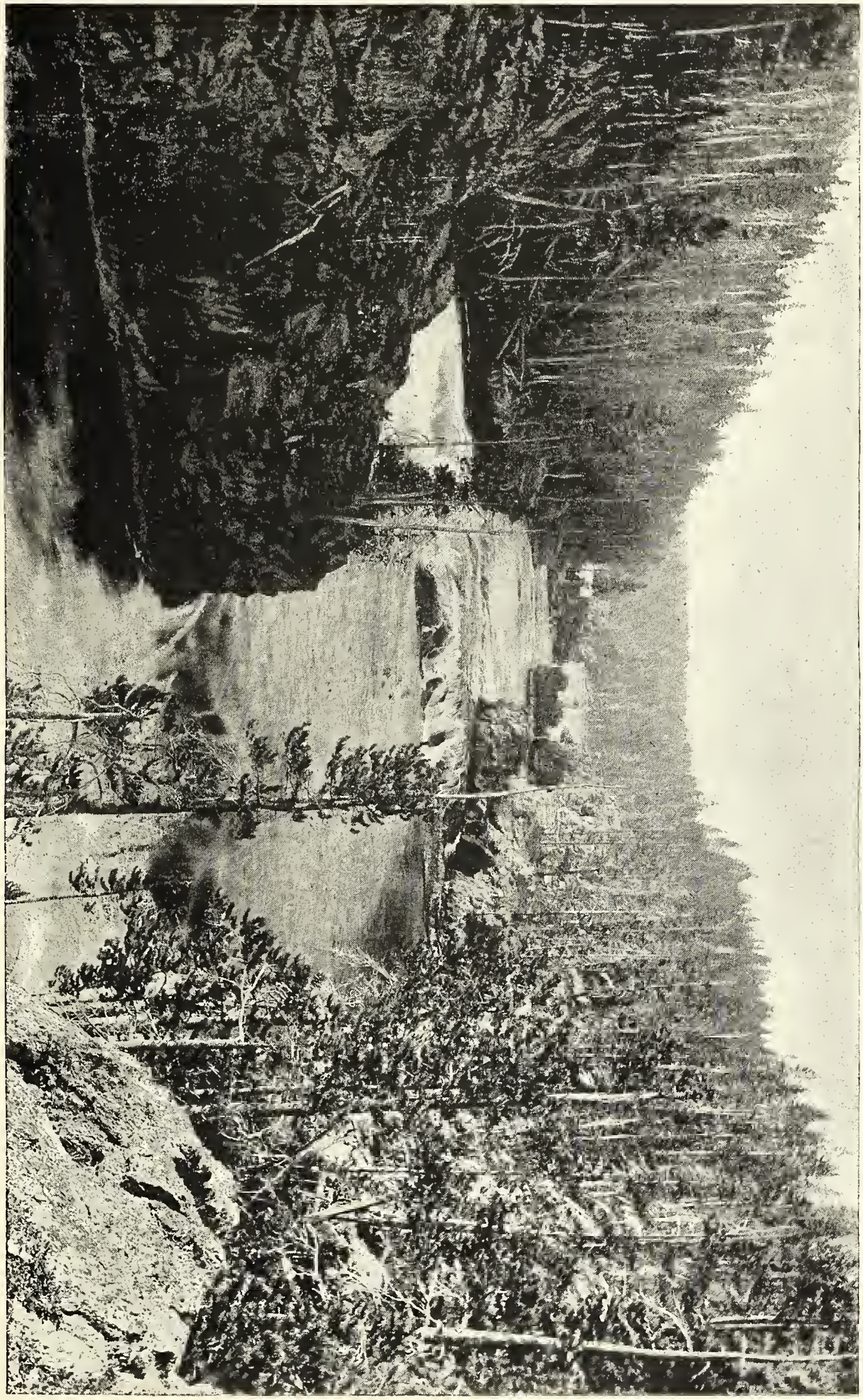
I have no specimens of the true northern *signifer*, but taking the figure published in the Natural History of Aquatic Animals, plate 195, as a basis of comparison, the grayling of Montana and Michigan may differ in the lower and less spotted dorsal and the slightly smaller scales (98 instead of about 92). Should these differences hold, it will stand as *Thymallus signifer ontariensis* (=*T. tricolor* Cope = *T. montanus* Milner).

9. Salmo mykiss Walbaum. The Red-Throated or Rocky Mountain Trout. (*Salmo purpuratus* Pallas: *Salmo stellatus, clarkei, virginalis, lewisi*, etc., of authors). (Plate X, Figs. 10 and 11.)

I have compared a large series of trout from the Park with trout from various other streams in the Rocky Mountain region. There seems to be no doubt that all the trout in the Park belong to a single species, and that this species is indentical with the common red-throated or black-spotted trout of the Lower Columbia, and of the coast rivers from Oregon to Kamtschatka. This species was first mentioned by Steller under its Russian name of *mykiss*. Later it received the binomial names—*Salmo mykiss* Walbaum, 1792, *Salmo muikisi* Bloch & Schneider, 1801, and *Salmo purpuratus* Pallas, 1811. Probably all the trout of the Rocky Mountain region belong to this single species, but certain marked varieties of it occur in waters of Colorado, of which a detailed discussion is given in another paper.

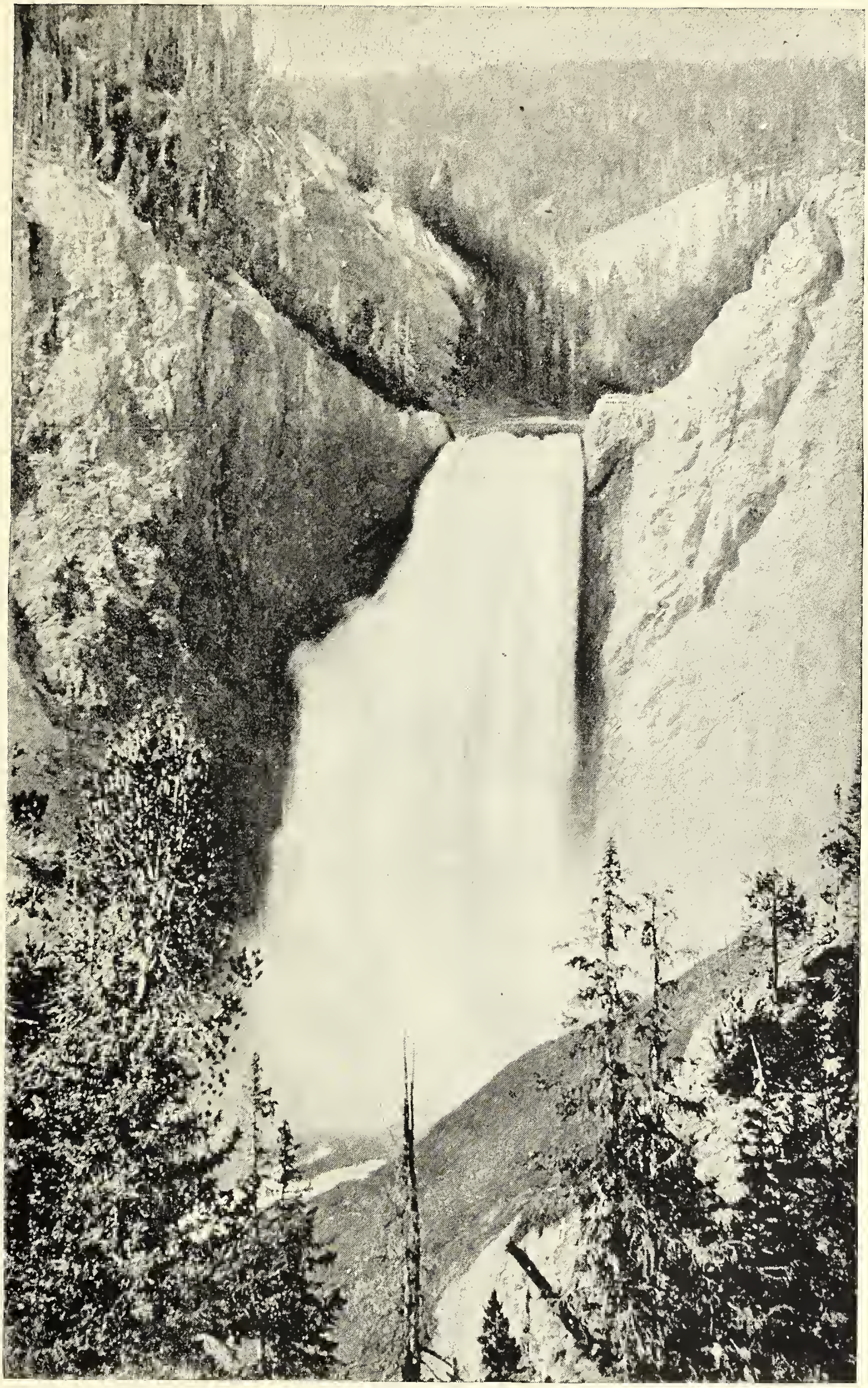
The trout of Yellowstone Lake seem to differ from those of Heart Lake and Henry's Lake in having the black spots larger and more distinct and rather less numerous. In these respects very much individual variation is shown. The trout from Heart Lake and from Henry's Lake are essentially like others from Walla Walla in this regard, and those from the Yellowstone below the falls have the spots generally smaller than in those from the lake. The trout of the Upper Missouri region have received the name of *Salmo lewisi* Girard, but I can not recognize *S. lewisi* as even varietally distinct from *S. mykiss*. In fact, as elsewhere stated in this paper, there is good reason to believe that the Yellowstone Lake was stocked originally from Snake River, through Pacific Creek, Two-Ocean Pass, and Atlantic Creek. It is, moreover, not unlikely that an interchange of individuals still occasionally takes place across the Continental Divide.

The trout of the Yellowstone Lake and of many of its tributaries above the falls are infested by a parasitic worm (*Dibothrium cordiceps* Leidy). Of the specimens ex-



YELLOWSTONE RIVER; RAPIDS ABOVE THE UPPER FALLS. (See page 54.)

UPPER FALLS OF THE YELLOWSTONE RIVER. (See page 54.)



LOWER OR GREAT FALLS OF THE YELLOWSTONE RIVER. (See page 54.)

amined by us from the Yellowstone, between the falls and the Lake, all showed some traces of the presence of the worm. These were first noticed by us as small whitish cysts, about as large as a grain of wheat, around the pyloric cœca, sometimes in the ovary. These cysts contain small worms, apparently similar to the larger ones. These larger worms, from 1 to 5 inches in length, are found in the liver, in the abdominal cavity, or in the muscular substance of the belly or sides. When worms exist in the flesh they can usually be found by skinning, as the flesh about them is more or less diseased. These facts may perhaps be better appreciated by the following notes on specimens examined:

Female (dissected) from Yellowstone River (taken like the next four in the eddy at the bend of the river, about 1½ miles above the Giant's Cauldron and Mud Geyser). A worm 10 inches in length, in a sac along the intestine; another worm about 4 inches long, in a sack, in the muscle of the abdominal wall, the flesh pale and diseased for an inch about the worm. Ovaries full of little worm cysts, and imperfectly developed. Numerous cysts among the pyloric cœca in this and all other diseased specimens.

A large male (No. 137): Liver, pyloric cœca, and spleen with worms; the worm in liver large. Testes wholly empty and shrunken. Had external appearance of a female trout.

Male (421): No worms evident, except a few cysts about the stomach; testes full and normal.

Female; No worms evident; ovaries large and full of normal eggs; cysts present among the pyloric cœca in this and all other specimens from Yellowstone River.

Male (285); Pyloric cœca full of cysts.

Males (323, 244); Worms present; sexual organs little developed.

Nos. 3 and 4, Riddle Lake. Viscera normal; no trace of worms or cysts.

Female (494); from Heart Lake, at mouth of Witch Creek; intestines and cœca with cysts and with some small worms. Other worm-like parasites of other genera in cavity of mouth and on dorsal fin.

Young male (365); Heart Lake: a single small encysted worm among the pyloric cœca; no others evident.

A basket of dressed trout, taken in the Yellowstone River at Livingston was examined. Among these was one worm 3 inches long, apparently of the same species as the others. Numerous other specimens were examined without developing any facts other than those included below.

I offer the following generalizations with much hesitation, as I know practically nothing of the life-history of intestinal worms of the group to which *Dibothrium* belongs.

Worms are found more or less abundant in nine-tenths or more of the grown trout in the Yellowstone Lake, and its larger tributaries, and in the Yellowstone River as far as the Lower or Great Falls. The trout in the upper Yellowstone are likewise affected, those in Bridger's Lake being (according to Mr. Arnold Hague) largely wormy, as also those in Atlantic Creek (Elwood Hofer). The small trout (under 6 inches) have not been found to contain worms.

Worms are popularly believed not to exist in the Lower Yellowstone (below the falls). The discovery of a worm at Livingston would contradict this. Perhaps worms exist, but are small or scarce. Those in the encysted condition would hardly attract popular notice, for ordinary observers do not even distinguish the worms from the pyloric cœca.

Worms certainly exist in the trout of Heart Lake, to all appearance identical specifically with those in Yellowstone Lake. This lake is on the west side of the Divide and is drained by Snake River. It has at present no connection with Yellowstone Lake.

Yellowstone Lake and Heart Lake have one feature in common, and one shared by no other lakes containing trout with which I am acquainted (Shoshone and Lewis Lakes being destitute of fishes). Both have a large influx of hot water from geysers and from hot springs, some of them outside the lake, but many of them opening under the water. This suggests the theory that the existence of the worm itself, or perhaps its malignity as a parasite, is dependent on the presence of hot water, instead of the cold waters ordinarily frequented by trout.

As bearing on this suggestion I may notice: In both lakes the trout actually frequent the warm waters, attracted apparently by the great abundance of fish food to be found there. It is perhaps not impossible that with the great variety of insect, crustacean, and worm life, the germ of the worm may occur also. The streams in which wormy trout occur, so far as known, are all in easy access from Yellowstone Lake. Riddle Lake, although tributary to the Yellowstone, has an outlet long, narrow and tortuous, being dry at both ends in the summer. It is so difficult of access that probably trout do not often ascend it. Only young trout were seen in the creek, and the trout found in the cold waters of Riddle Lake showed no sign of worms. The trout in Pelican Lake and other waters to the east of Yellowstone Lake and tributary to it are said to be infested with worms. These lakes receive much water from Hot Springs.

Connected with this fact of the development of worms in warm waters is the fact that the suckers in the warm (largely geyser) waters of Witch Creek (*Catostomus ardens*) are afflicted with another parasitic worm. I know nothing of the history or relationships of this worm, but it is hard to avoid the supposition that the warm water favors its development. Although the sucker is a small fish, the worm infesting it is larger than any other parasitic worm I have ever noticed among fishes, and, as elsewhere stated, it often occupies more space in the abdomen of the fishes than do the fish's own viscera.

The lakes of Washington, Colorado and Utah, abounding in trout of the same species, show, as far as we know, neither geyser water nor *Dibothrium*.

It will be interesting to know whether the trout introduced into Lakes Shoshone and Lewis, both of them with similar hot tributaries, will be afflicted with worms. It will also be interesting to know whether any other species of trout will show immunity from them. Possibly an abundance of other fishes as food for trout would draw them away from the hot waters, and free them from worms.

The "wormy" trout are leaner and more compressed than others, and the sides of the belly are likely to show ridges and lumps. The flesh is said to be redder in the diseased fish, and the external color is more likely to be dusky or brassy.

In the trout examined the presence of many worms was accompanied by a shrunken or irregular condition of the ovaries or testes. Perhaps spent fish are more likely to be wormy. According to Mr. Arnold Hague, the best trout are in swift or deep waters; the wormy ones about eddies or among logs or masses of floating vegetation. The wormy trout takes the fly freely but is in general little gamey. In fact, all the Yellowstone trout seem less active than is usual for the species.

The value of these attempts at generalization can only be determined by the thorough study of some competent helminthologist in the field. The life-history of the worms is yet to be made known. When this is done possible remedies may be suggested. The probabilities are that the trout and the worm will never be divorced in Yellowstone Lake.

PLATE XIV.

CRYSTAL FALLS OF CASCADE CREEK. (See page 55.)

It is said the bears are often seen going about the shores of the lake picking up the dead fish.

10. Cottus bairdi Girard. (Var. *punctulatus.*) (Plate X, Fig. 12.)

The "Miller's thumb" or "blob" is found in great abundance in the grassy bottoms of Madison River, Gibbon River, and Cañon Creek. In Gibbon River it is found above the falls as well as below it, an anomaly of distribution as yet unexplained, unless we call in the aid of the Osprey or some similar agency. It is said that the species is found also in the Yellowstone below the Park.

The specimens taken by us in the Gibbon and Cañon Creeks, as well as those procured by Mr. Lucas in Horsethief Spring are identical with specimens taken by us from Eagle River, Colorado, and in other tributaries of the Colorado. All of them belong to the variety or species named *Potamocottus punctulatus* Gill, although the dark spots are generally coarser and more diffuse than is shown in Professor Gill's figure.*

In the specimens from the Park the band of palatine teeth is broad; there are no prickles on the skin. The head is 3½ in length and the rays are D. VII–17; A. 13; V. I, 4.

Comparing these with specimens (*Cottus bairdi carolinæ*), from Mammoth Spring, Missouri, the differences seem well marked. Var. *punctulatus* has the head blunter, lower and more rounded, the cheeks more tumid and the top of the head without median longitudinal depression. Var. *carolinæ* has the axil prickly, the outline of the head angular, the top of head with a median longitudinal depression from snout to nape, and the body has broad distinct black cross-bars.

These two forms seem like distinct species, but other specimens are intermediate; specimens from Torch Lake, Michigan, agree with *punctulatus* in color, and are intermediate in form; specimens from White River, Indiana, are colored like var. *carolinæ*, but are intermediate in form. Apparently *punctulatus* should be recognized as a subspecies but its range and distinctive characters are yet to be made out in detail.

THE STREAMS AND LAKES OF THE PARK.

The following is the substance of our field-notes on the physical characteristics of the streams and lakes of the Park:

YELLOWSTONE BASIN.

THE YELLOWSTONE RIVER.—The Yellowstone River drains an area of 1,900 square miles, or about half the surface of the Park. It has its rise in the Continental Divide, to the southeastern limit of the Park. One of its tributaries, Atlantic Creek, flows to the eastward by the side of a low part of the Divide, known as Two-Ocean Pass. On the opposite side of this pass, at a distance of about one-eighth mile, flows Pacific Creek, in the opposite direction, though parallel with Atlantic Creek. Pacific Creek is a tributary of Snake river. The Divide between the Yellowstone and Snake River is a marshy meadow, more or less overflowed in spring, its whole width scarcely more than an eighth of a mile. It is supposed that the stock of trout in the Yellowstone, above the falls, must have originally come from Pacific Creek. Whether the lower Yellowstone and the upper waters of the tributaries of the Missouri were stocked in this way is less certain. If the trout of the Missouri came across Two-Ocean Pass

* Ichthyology Captain Simpson's Rept. Expl. Basin of Utah.

the whitefish might have done so also; but this is unlikely, as no whitefish are now in Yellowstone Lake nor in Yellowstone River above the falls. The Yellowstone is a very clear, cold stream (temperature 50° to 60°), and, taking its whole extent, it is one of the most picturesque in America. It flows through a large glacial depression in which it expands to form the Yellowstone Lake (7,741 feet elevation). This is a large body of water, of very irregular form, which is often compared to that of an uncouth hand with a very large thumb and three shrunken fingers. Its greatest length, north and south, is about 22 miles, and its greatest width across the thumb is about 15. West and south of the lake are high mountains, and the lake banks are, in many places, bold and rocky, the hills being covered with pine and fir trees. Toward the north end of the lake the banks are lower, and here terraces show previous greater extension, covering the marshy pastures and woodlands of its outlet, the territory known as Hayden Valley.

Above the lake the Yellowstone River winds through marshy meadows, between wooded hills, behind which are the rugged peaks of high volcanic mountains. The current is sluggish above the lake, and between the lake and the upper falls there is also no great descent. The river below the lake is bordered by low hills, some of them wooded, others forming open grassy pastures. Below the lake the large river flows for about 15 miles with a quiet current, then plunges into a deep cañon over two vertical falls 109 feet and 308 feet in height (see plates XI, XII, XIII). This famous cañon, which needs no description here, is more than 20 miles long, with nearly perpendicular walls, 800 to 1,100 feet in height. The current of the stream below the falls is swift until it leaves the Park. The Yellowstone retains its general character as a clear, cold, and swift river for almost its whole course through Montana until it joins the Missouri. Trout abound throughout from the source of the river in the mountains as far as Livingston, and doubtless for many miles beyond. Above the falls the river contains no other kind of fish. The abundance of trout above the falls is remarkable. In one eddy in the river, eleven, averaging 1½ pounds each, were seen together, and in parts of the lake they are as numerous as in the river. They are everywhere eager to take the fly, but they are regarded as indifferent fighters in comparison with the trout of other streams.

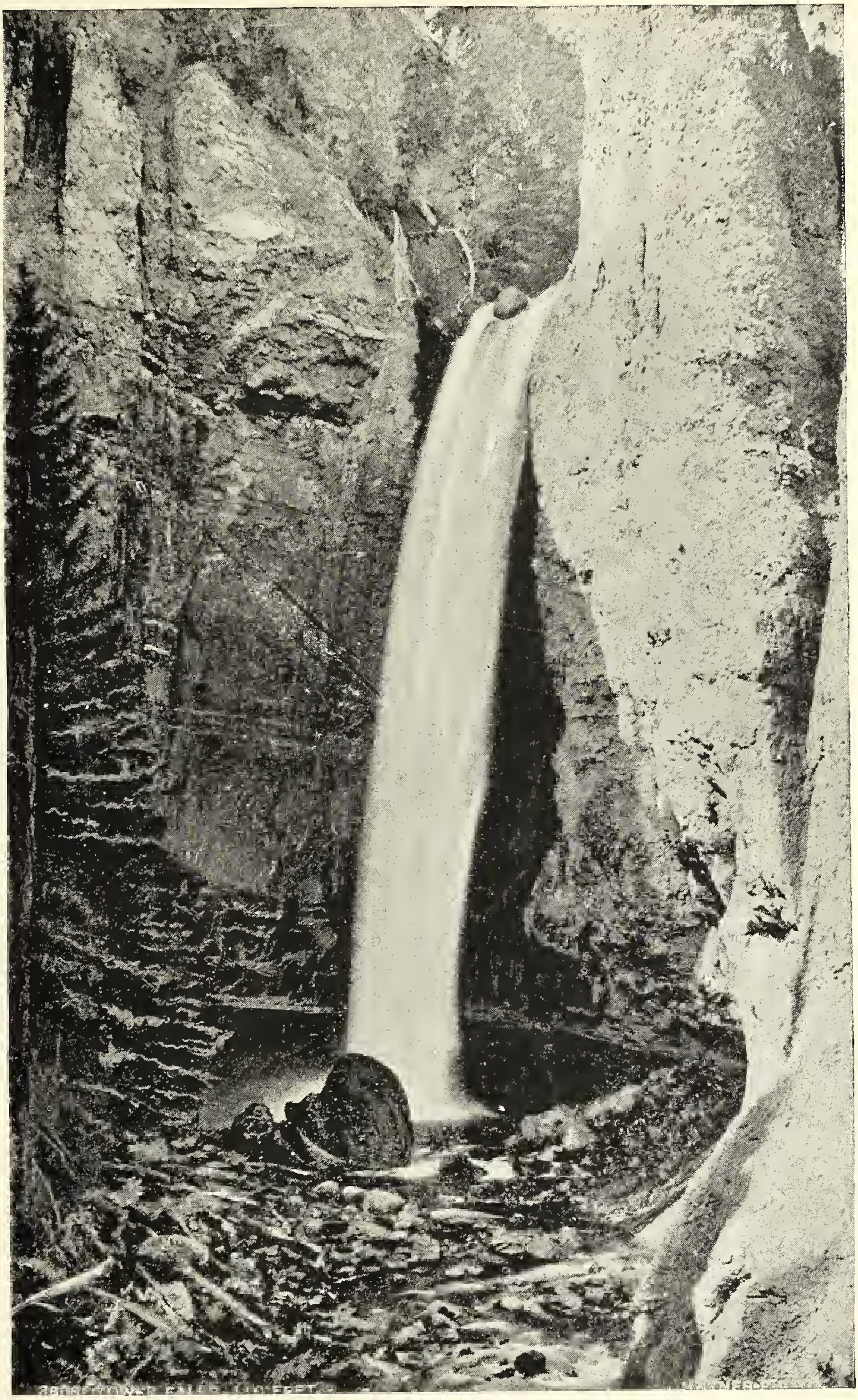
In Yellowstone River, and in most parts of the lake, fish-food, such as insects, crustacea, larvæ, etc., are very abundant. The stomach of one trout taken in the river contained helgramites (larvæ of *Corydalus*), grasshoppers, and caddis-worms.

Of the tributaries of the Upper Yellowstone, none were visited by us. Common report says that all are well stocked with trout, and that the trout in all or most of them are wormy.

The following tributaries of the lake were examined:

Solution Creek is a small, narrow stream, with lava bottom and grassy banks lined with willows. At the time of our visit it was dry for 2 or 3 miles above its mouth, and for about the same distance below its source in Riddle Lake. In the standing pools of its middle course were numerous young trout.

Riddle Lake (so called because of the mystery of its outlet, "solved" by the discovery of the little creek) is a clear pond of roundish outline about 1½ miles in diameter. About its outlet are numerous lily-pads and other plants. Its shores are shallow, and its bottom chiefly lava gravel. Trout seem to be numerous in the pond. Two were taken, one a female with full ovaries, the other a male with shrunken testes.



TOWER FALLS OF TOWER CREEK. (See page 56.)

Both seemed to be free from worms. There is no evidence of hot-water action in Riddle Lake. The temperature of the lake is about 50°.

Bridge Bay Creek is a small brook of no importance.

Arnica Creek is a similar stream, the water of which is warmed by hot springs. No trout were seen there.

Trout Creek is a clear stream with grassy banks and gravel bottom. Water clear and clean, about 58°. Its course lying chiefly in Hayden Valley it has no falls. No fish were seen, although it is said to be a fair trout stream but inferior to the next.

Both of these enter the Yellowstone River from the west some 12 miles below the lake.

Alum Creek is a clear stream about 8 feet wide and 1 or 2 feet deep, rising in the Continental Divide opposite the head of Nez Percé Creek and flowing eastward through the grassy fields of Hayden Valley. Its bed contains much white alkali from the hot springs above and there is a perceptible alkaline taste to the water. Its temperature is about 60°. In its upper course it has some hot tributaries, one of these, Violet Creek, with a number of hot springs and mud-holes. Still another fork is charged with alum. A third branch is said to be one of the best trout streams in the park. One small trout was noticed while fording this stream, a fact which tends to show that alkaline and warm waters are not specially avoided by trout.

Sour Creek, a large stream, entering the river opposite Alum Creek, was not examined nor was the cause or degree of its sourness made out.

Cascade Creek, a clear brook about 3 feet wide, enters the Yellowstone between the falls. The high, nearly vertical "Crystal Falls" (129 feet) is near the mouth of the stream and, of course, prevents the ascent of fishes (see plate XIV). It is said that fifty trout from the Yellowstone were placed in Crystal Lake, a pond toward the head of this stream, last spring by Mr. Cummings. The planting of Yellowstone trout in streams without trout has been since forbidden on account of the danger of the spread of the parasitic worm.

Sulphur Creek, a small clear stream having in its course numerous sulphur springs and boiling sulphur holes, flows into the grand cañon. It has, of course, no fish. Another small stream, Surface Creek, with a very high cascade, "Silver Cord," flows into the cañon from the opposite side.

Lamar River, or east fork of the Yellowstone, is a large stream, flowing into the Yellowstone from the east at a point below its cañon.

This is well stocked with fish, as are its tributaries, the chief of which are Slough Creek and Soda Butte Creek. These streams were seen by us only from a distance. At Baronette's Bridge, at the mouth of Lamar River, a trout was taken which weighed 4 pounds 4 ounces, when dressed. It was 16 inches long.

Slough Creek is said to be well stocked with fishes up to the lakes at its head which is near the mining camp of Cooke City, Mont. One of these lakes is said to be without trout on account of the presence of much iron in its outlet, so much that the bottom is red. Another has no trout but multitudes of "blob" (*Cottus bairdi punctulatus*). This stream has a small water-fall in its outlet. Still another, "Lake Abundance," is said to be full of trout.

Soda Butte Creek is well stocked with fish except in its upper part where a waterfall keeps them back.

Hellroaring Creek flows into the Yellowstone from the north below the mouth of

Lamar River. Its lower part is well stocked with fish. The upper part is almost unknown. Its rise is seen to be in high granite mountains, and in its course there are probably numerous cascades. According to Gannett "it comes from the granite portion of the range north of the Park, cutting a tremendous gorge through it." At the foot of the gorge is a sharp conical peak of granite known as Hellroaring Mountain.

Crevice Gulch, the next stream on the right bank, is beyond the limits of the Park. It is said to contain both trout and whitefish.

Antelope Creek, on the left bank, is a small stream flowing down a grassy slope on the south side of Mount Washburn. This stream has no cañon and no distinct cascade and is fairly stocked with fish.

Tower Creek is a larger stream, draining the semi-circle of mountains of which Mount Washburn is the highest, a group, according to Gannett, comprising twenty-five summits ranging in height from 9,000 to 10,400 feet. The current of Tower Creek is swift and for almost its whole length the stream is hidden in dense forests. It is, perhaps, the coldest stream in the Park (about 45°). About one-fourth mile from its mouth (at which point this stream is separated by a narrow lava ridge from Antelope Creek) Tower Creek forms a singularly picturesque fall of 132 feet (see plate XV). This fall is quite vertical and it is surrounded by lofty pillars or towers of volcanic conglomerate. Below the fall is a deep and narrow cañon. The stream is here some 10 feet wide by 1 deep. There are no fish above the falls but for those species of trout which are especially fond of cold and shade no better stream exists in the Park.

Lost, *Elk*, *Geode* and *Oxbow Creeks* are small steams—too small to be of consequence for fish. Although having a large bed Oxbow Creek was entirely dry in October and the other streams had little water.

Black-tail Deer Creek is a clear, rather cold stream (55°) running largely through open pastures, with willows along its course. It has no cañon or falls. Its bottom is of lava gravel and rocks with some weeds. It is 5 or 6 feet wide by 1 or 2 deep, and is well stocked with trout. Young trout were seen in the little pool at the bridge, but no minnows.

Lava Creek or East Fork of the Gardiner River, is a clear mountain stream resembling Tower Creek, and like the latter flowing chiefly through evergreen forests on the north side of the mountain range. The stream is about 10 feet wide by 1 or 2 deep. Towards its mouth it cuts its way into a broad, flat shelf of lava, forming two successive cataracts about one-tenth of a mile apart. The upper falls, called Undine Falls, is vertical for about 30 feet, then with two additional leaps of about 20 and 10 feet (see plate XVI). The lower fall is vertical and about 50 feet high. Below this fall the stream flows through a highly picturesque cañon joining the Gardiner River, above Mammoth Hot Springs. In this cañon trout are abundant.

Lupine Creek is a small tributary of Lava Creek entering it above the falls. This stream has a high cascade (Wraith Fall), about 100 feet high.

Notwithstanding the barrier offered by Undine Falls, it is said, on good authority, that small trout have been seen in Lupine Creek below Wraith Fall (Elwood Hofer) and trout have been taken in Lava Creek above the falls. This raises the question as to how they came there. Our attention was called by Mr. Hofer, to the way in which trout may have crossed the Divide from Black-tail Deer Creek to Lava Creek.

UNDINE FALLS OF LAVA CREEK. (See page 56.)

The easternmost tributary of Lava Creek is a grassy slough with very little current. The narrow stream in its midst is nearly dry in summer. The same conditions extend to the summit of the Divide, which rises to the height of about 3 feet above a small pond with which the slough begins. The Divide is a rod or two across at its lowest part near the pond. On the east side of it, but lower down, is a similar pond with grassy surroundings, which flows into Black-tail Deer Creek. Into both these depressions considerable springs flow, especially into the one on the west.

The grassy slough first named, tributary to the Lupine Creek, has very little slope for a mile or more. Should its waters rise in spring so that the almost dry pond would be 3 feet in depth, this pond would overflow on both sides, and a continuous water-way would be made from Lupine Creek down into Black-tail Deer Creek. This water-course would be shallow, and is doubtless seldom traversed by fishes. It is, however, a possible one, and serves to account for the presence of trout in Lava and Lupine Creeks.

By order of the U. S. Fish Commissioner other trout from Howard Creek have this year been placed above the falls in Lava Creek.

Gardiner River (or *Middle Gardiner*) rises in the east slope of the Gallatin Mountains in the northwestern part of the Park. It flows eastward, southeastward, then abruptly northward, bending around Bunsen's Peak, and forming a deep cañon, toward the head of which is the large Osprey Falls (see plate XVII). Gardiner Cañon is some 800 to 1,000 feet deep, with vertical walls of lava, basalt, etc., and in grandeur is surpassed only by the Cañon of the Yellowstone. The Osprey Falls is about 150 feet high, and nearly vertical.

Trout are abundant in the river from the foot of the fall to its junction with the Yellowstone, some 4 or 5 miles below. No fishes have been seen in the Gardiner or any of its tributaries above the Osprey Falls except the brook trout (*Salvelinus fontinalis*), lately planted at the bridge below the mouth of Indian Creek.

Above the falls Gardiner River is a clear, cold stream (about 50°), with numerous stones, boulders, and deep holes. It is well provided with fish food.

Its principal tributaries above the falls are Obsidian Creek and Indian Creek, the latter coming in from the southwest, the former from the south. The largest of these, Obsidian Creek, heads in or near the Twin Lakes. There are two small ponds about one-half mile and 1 mile long, with no visible inlet, the small stream connecting them being dry in summer. The lower and smaller pond is said (by Mr. Lucas) to have large alum springs near its outlet, the water being so charged with alum that horses will not drink it. The outlet, Obsidian Creek, is at first very small, and its course for 2 or 3 miles is full of hot springs, solfataras, boiling mud-holes, and various similar heated areas offensive to fish. It is not likely that a fish could pass through this stream, except in very high water.

Lower down cold springs enter the stream, and at Beaver Lake the water is clear and cold. Beaver Lake is a shallow grassy pond, about a mile long, formed by the beavers. Three large beaver dams cross it, and each of these dams in ordinary seasons would be likely to block the ascent of fishes (see plate XVIII). The lower one especially is covered with brush, over which fishes could not leap. Below this lake Obsidian Creek receives the clear, cold waters of Winter Creek, a large stream which heads in Christmas Tree Park, at the foot of Mt. Holmes. The stream now flows through Willow Park, a large mountain meadow, in which it joins the Gardiner River.

Obsidian Creek with Winter Creek will, apparently, be one of the best of trout streams. Its temperature is about 50°. Its bottom of lava gravel is lined with grass, algæ, and water plants in which small crustacea swarm.

Indian Creek is a clear, cold stream, similar to the Gardiner, and like it, heading in the east slope of the Gallatin Mountains.

Glen Creek, or West Fork of the Gardiner, rises in Sepulchre Mountain and flows southeast, then northeast, joining the Gardiner at the foot of its cañon.

This is a small stream, which runs mostly through open meadows. It is 5 or 6 feet wide and 1 to 2 feet deep, with gravelly and grassy bottom. Its waters are very cold (about 48°) and full of crustacean life. The red-bellied frog, *Rana septentrionalis*, is abundant. Glen Creek has a high waterfall, some 70 feet high (Rustic Falls), at the "Golden Gate," near the base of Bunsen's Peak (see plate VIII).

Below the fall the deep cañon is so choked up with boulders and talus that fish can not ascend it. Above the fall Glen Creek receives a considerable tributary, which drains Swan Lake. Swan Lake is a small roundish pond, about half a mile long, with a bottom of crumbled lava. While its shores are very shallow, the depth in the center seems considerable. The waters are clear and cold, abounding in insects and crustacea. In Glen Creek and the Gardiner River 5,000 Brook trout, *Salvelinus fontinalis*, were placed in August of this year.

The lower course of the Gardiner, below the three falls (Osprey, Undine, and Rustic), is well stocked with trout and contains whitefish (*Coregonus williamsoni*), suckers (*Catostomus griseus*), and minnows (*Rhinichthys dulcis*). Below Mammoth Hot Springs it receives the scalding Hot River, the drainage of the springs. That these hot calcareous and sulphuretted waters are not destructive to fish life, even to that of trout, has been already shown. It is said that in winter the trout are especially abundant about the mouth of this stream.

MISSOURI DRAINAGE (730 square miles).

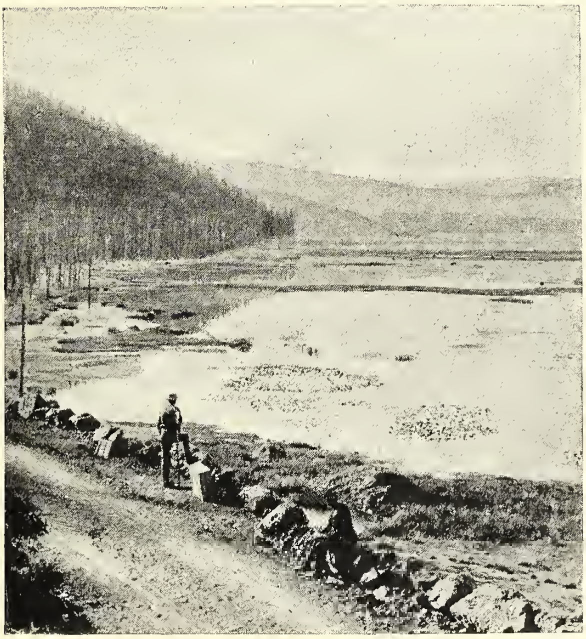
The three streams which unite near Gallatin City, Mont., to form the Missouri are the Jefferson, the Madison, and the Gallatin Rivers. Of these, the Jefferson lies outside the Park. The Gallatin and two little-known tributaries (Fan Creek and Grayling Creek) rise in the wild region west of the Gallatin Mountains in the northwest corner of the Park. These cold, clear streams, rarely visited by sportsmen, are said to be well-stocked with trout and grayling.

Madison River drains an area of 730 square miles in the Park; this includes the country to the west of the Yellowstone and to the north of the Continental Divide. The name Madison is only used for the river below the junction of its chief tributaries, the Firehole River and the Gibbon River.

Gibbon River, the smaller of the two streams, rises north of the center of the Park in the hills and marshes around Grebe Lake, a body of water not far from Crystal Lake, on Cascade Creek. Grebe Lake, about a mile long, surrounded by mountain meadows, is said (by Mr. Hague) to be one of the finest lakes in the Park. In the outlet of the lake above the falls known as Virginia Cascades, 1,000 rainbow trout (*Salmo irideus*) have been lately planted. The region about the upper course of the Gibbon is heavily timbered and its basin is separated by low divides from that of Obsidian Creek. Notwithstanding the influx of many hot springs, solfataras, soda springs, and even iron springs, the Gibbon remains a clear, cold river (55°) throughout its course. The Vir-

OSPREY FALLS OF GARDINER RIVER. (See page 57.)

RUSTIC FALLS OF GLEN CREEK. (See page 58.)



BEAVER LAKE; SHOWING BEAVER DAMS. (See page 57.)

ginia Cascade (some 60 feet high) will probably prevent the ascent of fish (see plate XIX). Below these cascades is the open valley of the Norris Geyser Basin, and still lower a broad meadow known as Elk Park. Several miles below Elk Park in a narrow cañon is the Gibbon Falls (80 feet high), a picturesque cataract, which trout certainly can not ascend (see plate XX). Above this fall are no trout, but an abundance of blob, or miller's thumb (*Cottus bairdi punctulatus*), and it is not easy to explain how they come to be there. Below the falls trout are abundant and, as in the Madison, grayling are said to be found.

Cañon Creek, a small clear stream, very cold and with grassy bottom, joins the Gibbon River below the falls. This stream flows through steep pastures, without falls except near its source. It is 6 to 8 feet wide and 1 to 3 deep, and is well stocked with trout. In this stream the blob is very abundant, absolutely swarming in the grass.

Firehole River, about twice the size of Gibbon River, joins it from the south. "This stream heads just west of Shoshone Lake, separated from it and from the head of Bechler River by relatively low divides" (Gannett). It flows through a small lake nearly dry in summer (Madison Lake), below which it receives a fine clear tributary from the east (Spring Creek). Along Firehole River are the most noteworthy of the geyser basins, and a great volume of hot water is poured into it without, however, rendering its waters at any point really warm, the average being probably 55° to 60°.

In its upper course, the Firehole, like the Spring Creek, is a clear and very cold stream flowing through dense woods, with narrow marshy valleys, alternating with small cañons. In this part of the stream 1,000 Loch Leven trout (*Salmo trutta levenensis*) were planted in September, 1889. Keppler's Cascades, above the upper geyser basin is a series of three or four very picturesque falls, some of them probably impassable to trout (see plate XXI). In the upper geyser basin the Firehole River receives the drainage of a multitude of hot springs, besides two considerable streams, also of mixed cold and hot water, the Iron Spring Creek and the Little Firehole River. The stream is here very clear. It is full of plants and other organisms, and its waters have a taste of decayed vegetation. Even at the midway geyser basin the stream is probably not too warm for trout. At the lower basin the Firehole receives the waters of Sentinel Creek, Fairy Creek, and the larger Nez Percé Creek. The latter, which comes in from the east, is nearly half as large as the Firehole and similar as to character and temperature of the water. It is fed by numerous short streams, some of them hot, and most of them confined to a narrow cañon. Some five miles below the mouth of the Nez Percé the Firehole, now a large river 2 to 3 rods wide and 2 to 5 feet deep, enters a wild cañon with banks of rough lava. In this cañon are the imposing falls of the Firehole, about 60 feet in height (see plate XXII), and forming an effective barrier to the ascent of fishes. Below this falls the common fishes of the Madison River, trout, whitefish, grayling, and blob, are said to be abundant. Lower down on the Madison River collections were made by Mr. E. R. Lucas, and a series of specimens given to us with the following notes:

"On October 2, I collected from Horsethief Spring 2,000 whitefish, which I planted next day in the Twin Lakes. Horsethief Spring heads in the Divide in Montana and flows 1½ miles, emptying into the North Fork of the Madison River. The first half mile of this stream is of a rocky bottom, with no growth of moss or grass. The second half mile is of white sandy bottom, completely filled with a growth of moss and some

grass. This moss is alive with fish food (specimens of which were sent). On October 15, I collected 1,000 more whitefish and planted them in Yellowstone River, above the falls. There are unlimited numbers of these whitefish in Horsethief Spring, running in size from 2 to 5 inches. There are also quite a large number of grayling in the stream."

Besides the grayling and whitefish, numerous specimens of the blob were taken in Horsethief Spring.

COLUMBIA RIVER DRAINAGE (682 square miles).

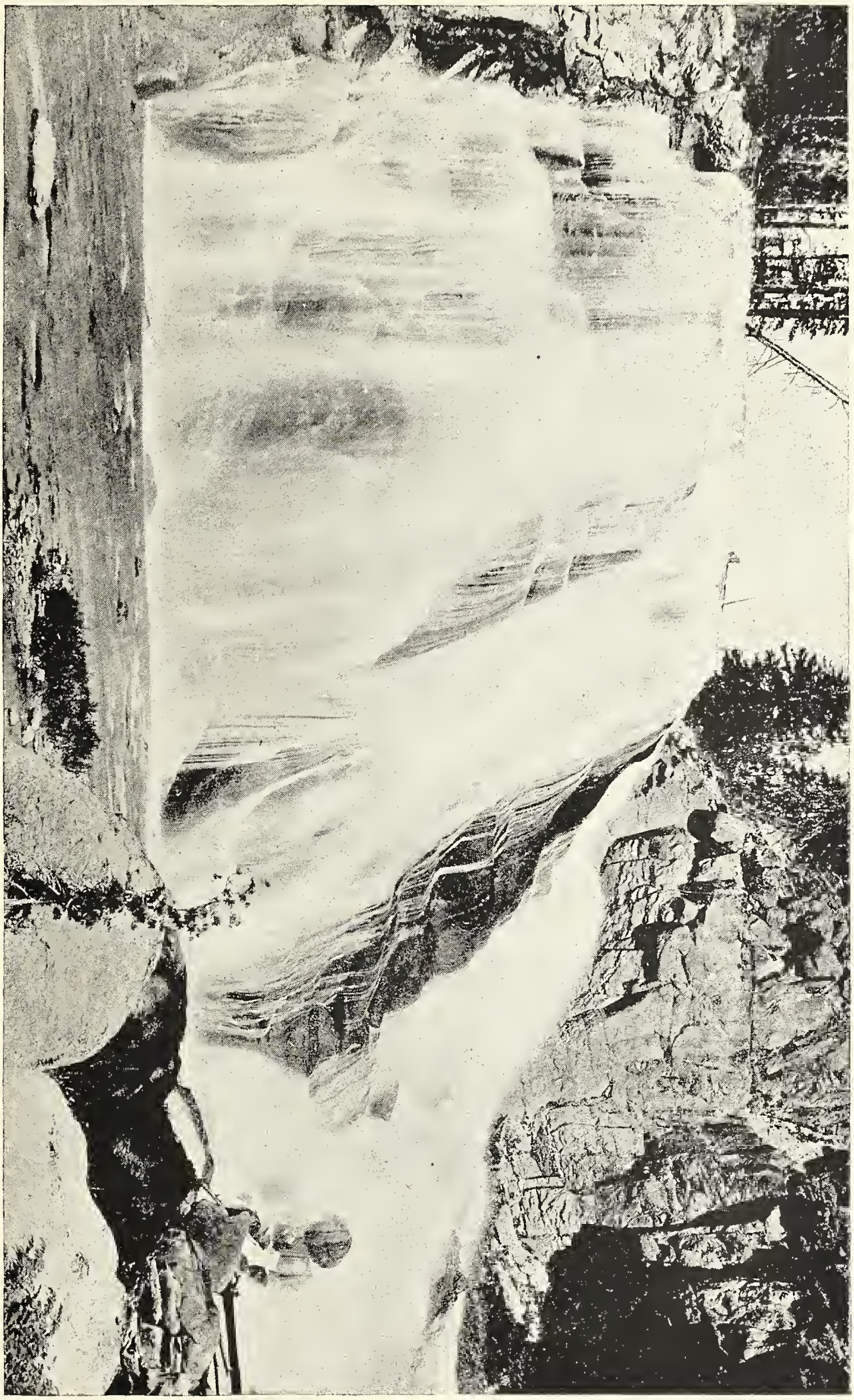
The Snake River, the largest tributary of the Columbia, drains that part of the Park (nearly one-fourth of the whole area) which lies to the southwest of the Continental Divide. This large territory is chiefly a densely wooded plateau and contains three large lakes, Shoshone, Lewis, and Heart, the largest lakes in the Park, next to the Yellowstone. Two of these lakes, with their tributary streams, are without fish, but the other rivers, Snake, Heart, Falls, and Beehler, are said to abound in trout except in certain of the headwaters where their ascent is prevented by water-falls (see plate XXI). As only a small part of this region was visited by us, I shall speak of the waters actually examined.

Heart Lake (elevation 7,469 feet).—This beautiful little lake lies in a deep depression at the eastern foot of Mount Sheridan and Red Mountain. It is about 3½ miles long from northwest to southeast and not quite 2 miles broad. Its bottom is of lava gravel, rather shallow near shore but becoming deep in the middle. It is drained by Heart River, a considerable tributary of Snake River, without falls, and said to be well stocked with fish. Near the head of the lake and in the lake are numerous geysers and hot springs. In the lake were found trout (*Salmo mykiss*), slightly afflicted with the same worm that is found in the Yellowstone. These trout were most numerous about the mouth of Witch Creek, and several were taken without the fly after chubs had been thrown into the lake to lure them. These chubs are eagerly swallowed by the trout. Besides these trout, a sucker (*Catostomus ardens*), chub (*Leuciscus atrarius*), shiner (*Leuciscus hydrophlox*), and minnow (*Agosia nubila*), are found in the lake. All of these except the trout ascend Witch Creek. A blob (*Cottus*) is also in the lake, but we were unable to catch specimens of it. There is plenty of fish-food in the lake and the water is not very cold, its temperature varying according to the nearness to the hot springs and geysers.

Witch Creek has its rise 2 or 3 miles above the lake, in the singular collection of geysers, hot springs, and steam holes known as "Factory Hill." Its water is at first scalding hot, but it gradually cools, receiving the waters of one cold tributary as large as itself. The chubs ascend until they reach water fairly to be called hot, and the sucker is not far behind. The lower course of Witch Creek winds through grassy meadows with a bottom of fine lava gravel and sand. In this part of the stream fishes are excessively abundant, chiefly suckers and chubs. As already noticed, the suckers are here infested by a very large parasitic worm, but no worms were seen in the chubs. Witch Creek has at its mouth a temperature of about 75° F.

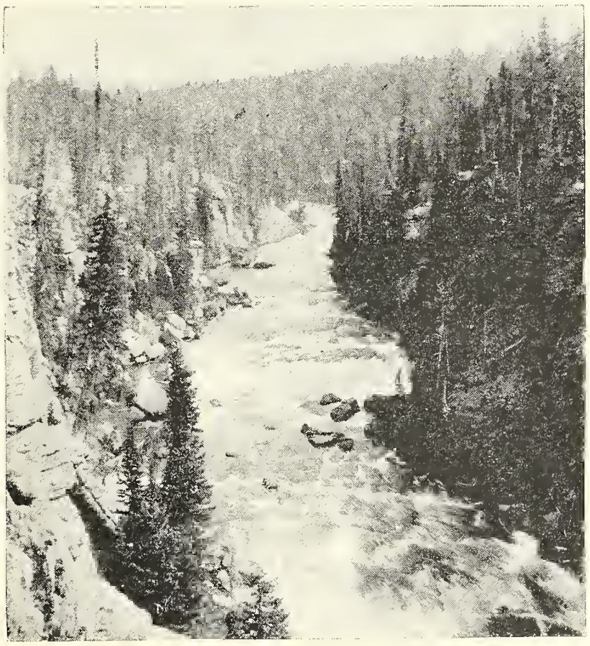
Shoshone Lake (elevation 7,740 feet) has a length of about 6½ miles and a width of one-half to 4½ miles, it being dumbbell shaped or constricted in the middle. Its area is about 12 square miles. At the head of the upper and smaller lobe of the lake is Shoshone Creek, fed by numerous hot springs and geysers. No hot springs exist on the

VIRGINIA CASCADE OF GIBBON RIVER. (See page 59.)



GIBBON FALLS OF GIBBON RIVER. (See page 59.)

KEPPLER'S CASCADE OF FIREHOLE RIVER. (See page 59.)



RAPIDS ON LEWIS FORK OF SNAKE RIVER. (See page 60.)

lower part of the lake. Its shores are mostly bold, rocky, and densely wooded, the eastern shore being especially abrupt, and the bottom is there made by large boulders of lava. There are no fishes in the lake. Along the eastern shore there is little fish-food, the lava rocks being barren, but the amount of water plants, lily-pads, etc., drifted on shore by the wind shows that a different condition must exist at the other end of the lake. Some crustacea and insects were noticed even on the east side. The lake is clearer and colder than either Yellowstone Lake or Heart Lake, and its mountainous shores render it extremely picturesque.

Heron Creek is a small grassy stream suitable for trout, flowing into the northeast angle of Shoshone Lake. It has now no fish life.

The outlet of Shoshone Lake is called *Lewis River*, a broad, swift, very clear stream, well provided with fish-food. This beautiful stream flows with a sluggish current for about 3 miles, where it expands suddenly forming the following lake:

Lewis Lake (elevation 7.720 feet).—This lake occupies a rounded basin with rather low banks. It is pear-shaped, about 3 miles long by 2 broad, very clear and cold and apparently in every way suited for trout. Its bold shores are heavily wooded and without tributary streams. A few hot springs, not seen by us, enter it on the western side. Below Lewis Lake, Lewis River enters a deep and narrow cañon, very rarely visited, and which lack of time prevented us from examining. According to Mr. Arnold Hague, there is at the head of this cañon a cascade of about 80 feet, of which 20 feet at the top is perpendicular. Toward the end of the cañon, above its junction with Snake River, is another cascade of some 50 feet in height, concerning which we were unable to secure information. Fishes are unable to ascend the upper fall, and perhaps the lower one also.* Near the lower fall is the mouth of Crawfish Creek, which has a considerable cascade called Moose Fall. In this creek crawfishes (*Astacus*) are said to abound.

None of the streams in the valley of Falls River in the southwestern part of the Park were examined. This region is said to be rather level, full of ponds, marshes, and springs. Here trout are reported to be very abundant.

Trout were also procured by Mr. E. R. Lucas, of the Fish Commission, in Howard's Creek, Idaho. Mr. Lucas gives us the following notes:

"On October 14, I collected 1,000 black-spotted trout from Howard's Creek, and on October 16 I planted them in the East Fork of the Gardiner River (Lava Creek) above the falls. Howard's Creek is the headwater of Henry's Lake. It rises in the mount-

* Prof. Frank H. Bradley (Report U. S. Geol. Survey, 1872, p. 256, *fide* Gannett), thus speaks of Lewis River:

"In descending from Lake Lewis, the party found the river-banks low and rocky for a short distance before the stream enters a cañon with walls 150 to 200 feet high, in which were encountered sharp rapids and a vertical fall of about 30 feet. Then for a mile or two the slopes are gradual with narrow, swampy bottoms along the river. About 3 miles below the lake high, rocky banks indicate the approach to a deep cañon which really commences at about 3½ miles, with perpendicular walls on both sides inclosing a narrow channel with a rapidly-sloping rocky floor, in some places partially obstructed by huge tumbling masses of rock, but apparently without any accumulation of gravel. Considerable rapids occur through nearly the whole cañon, and one fall of nearly 50 feet was noticed. The cañon deepens rapidly to from 700 to 800 feet, with width of less than half the depth at the deepest precipitous portions. * * * About 3 miles down it reaches its culmination and is truly grand. It has none of the brilliancy of coloring so characteristic of the Yellowstone Cañon, but the sombre tints of its gray, brown and dark-red lichen-covered rocks, variegated with smaller patches of green and yellow, constitute a peculiar style of beauty and add greatly to the effect of its narrow dark depths."

ain (Continental Divide) and flows about 2 miles, emptying into Henry's Lake. Howard's Creek is very small, averaging not more than 6 feet in width, and 6 to 12 inches deep. The bottom of this stream is mostly covered with small stones, in places a mud bottom. It contains no vegetable growth, except grass along its banks. There are no fish in this stream except trout, ranging from 1 inch to 4 inches in length. I caught 1,000 of these fish in about one hour and a half. It is impossible to estimate the number of trout that could be caught in this stream."

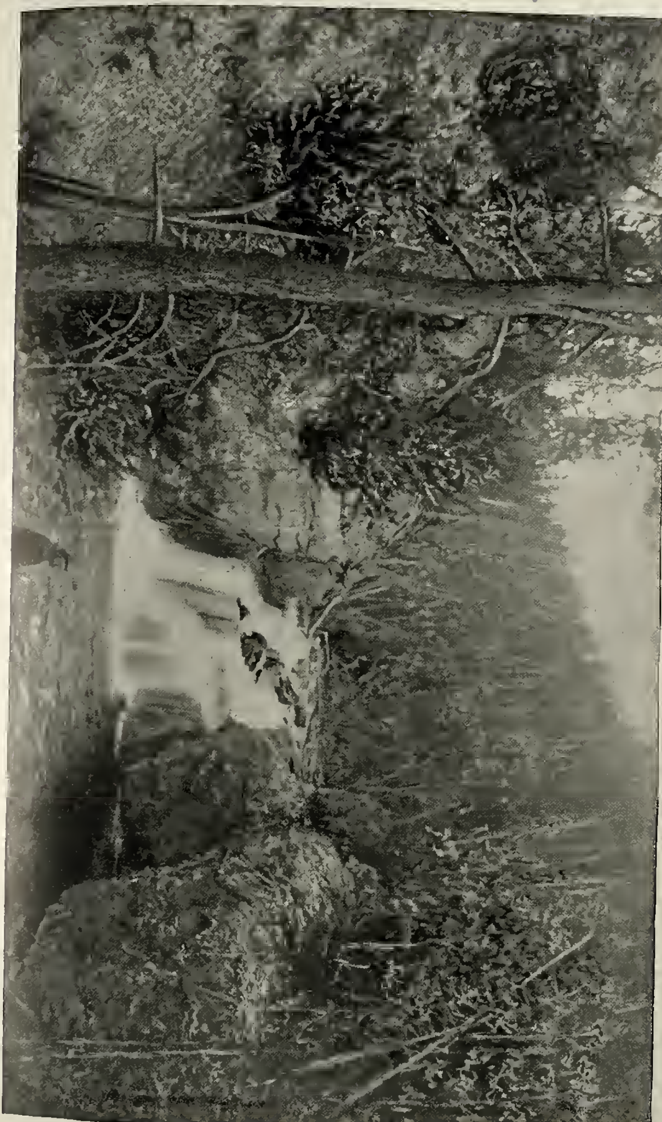
The following is a classified list of the lakes and streams in the Park (including a few outside its southern boundary) suitable for trout. Those in which trout are supposed not to exist are indicated by a star.

Upper Yellowstone River:
- Atlantic Creek.
- Jay Creek.
- Bridger Lake and Creek.
- Falcon Creek.
- Thoroughfare Creek.
- Escarpment Creek.
- Cliff Creek.
- Lynx Creek.
- Phlox Creek.
- Mountain Creek.
- Badger Creek.
- Trapper's Creek.

Yellowstone Lake:
- Beaverdam Creek.
- Rocky Creek.
- Elk Trail Creek.
    - Chipmunk Creek.
    - Riddle Lake and Solution Creek.
    - Arnica Creek with Beech Lake.
    - Columbine Creek.
    - Clear Creek.
    - Turbid Lake* and Bear Creek.
    - Pelican Creek.

Lower Yellowstone River:
    - Sour Creek.
    - Trout Creek.
    - Alum Creek.
    - Crystal Lake and Cascade Creek.*
    - Broad Creek.*
    - Deep Creek.*
    - Antelope Creek.
    - Tower Creek.*
    - Lamar River.
        - Cold Creek.
        - Willow Creek.
        - Timothy Creek.
        - Miller Creek.
        - Calfee Creek.
        - Cache Creek.
        - Soda Butte Creek, Pebble Creek, Amphitheatre Creek.
        - Slough Creek with Buffalo Creek, Lake Abundance, etc.
    - Hellroaring Creek.

PLATE XXII.



LOWER FALLS OF FIREHOLE RIVER. (See page 59.)

Lower Yellowstone River—Continued.
- Black-Tail Deer Creek.
- Gardiner River.
  - Lava Creek, Lupine Creek.
  - Obsidian Creek* (with Twin Lakes,* Obsidian Lake,* Beaver Lake,* Lake of the Woods*), Winter Creek,* Straight Creek,* with Grizzly Lake.*
  - Indian Creek.*
  - Panther Creek.*
  - Fawn Creek.*
  - Glen Creek,* with Swan Lake.*

Gallatin River:
- Gallatin Lake.
- Fan Creek.
- Grayling Creek.

Madison River:
- Gibbon River:* with Grebe Lake.*
  - Solfatara Creek.*
  - Cañon Creek.
- Firehole River.*
  - Madison Lake.*
  - Spring Creek.*
  - Iron Spring Creek.*
  - Little Firehole River.*
  - Fairy Creek.*
  - Goose Lake.*
  - Sentinel Creek.*
  - Nez Percé Creek* (with Aspen,* Spruce* and Magpie* Creeks).
- Cougar Creek.
- Maple Creek.
- Gneiss Creek.

Snake River:
- Fox Creek.
- Crooked Creek.
- Sickle Creek.
- Pacific Creek.
- Heart Lake and Heart River.
  - Witch Creek.
  - Beaver Creek.
  - Surprise Creek.
- Basin Creek.
- Coulter's Creek, with Harebell and Wolverine Creeks.
- Red Creek.
- Forest Creek.
- Lewis River.*
  - Shoshone Lake,* with Shoshone Creek,* Moose Creek,* and Heron Creek.*
  - Lewis Lake.*
- Crawfish Creek.*
- Falls River with Beula,* Hering* and Grassy* Lakes.
  - Mountain Ash Creek.
  - Bechler River.

3.—ON TWO SPECIES OF LARVAL DIBOTHRIA FROM THE YELLOWSTONE NATIONAL PARK.

BY EDWIN LINTON.

[Plates XXIII to XXVII.]

In December, 1889, I received an interesting lot of entozoa, collected in the Yellowstone National Park by Dr. David S. Jordan of Bloomington, Ind., chiefly during October, 1889. The collection submitted to me for examination consists of two trout (*Salmo mykiss*), with the viscera of three others, four suckers (*Catostomus ardens* J. & G.), and a few large *Ligulæ* that had been removed from the abdominal cavity of the latter host. The trout were obtained in the Yellowstone River just below the lake, while the suckers were from Witch Creek, a hot tributary of Heart Lake.

Dr. Jordan states that the parasites of the trout first appeared, so far as he observed, in cysts among the pyloric cœca, later in the liver and among the viscera, and finally reaching a length of 5 inches in the flesh of the abdomen. These parasites were found in all trout in lakes fed in part by geyser-water, the trout abounding in the warm water in consequence of the abundance of food there.

Of the suckers he states that they abound in the warm waters, ascending to the temperature of 80° or more. About one in four has a very large parasitic worm in the abdominal cavity, where it is often as large as the whole viscera, and lies along the middle line of the belly. These worms were often more than a foot long and $\frac{1}{4}$ inch broad.

REMARKS ON THE GENUS LIGULA.

The generic name *Ligula* has long been used for certain cestods of the family *Dibothriidæ* (*Pseudophyllidæ* Van Beneden). The genus was distinguished from the genus *Dibothrium* (*Bothriocephalus*) chiefly by the absence of distinct segments in the body. The forms referred to this genus are common in many of the fresh-water fishes and are especially abundant in the *Percidæ* and *Cyprinidæ*, where they occur in the abdominal cavity and body-wall of their host. The adult stage has not been found in fishes.

The admirable researches of Duchamp (1876) first proved the identity of the Ligulæ of fishes with forms which are adult in the intestines of different aquatic birds. Duchamp's investigations were on an abdominal Ligula of the tench (*Tinca vulgaris*). This Ligula has a most extensive synonymy, but the name which has priority is *L. simplicissima* Rudolphi. Diesing (1864) recognizes two species of *Ligula*, viz, *L. monogramma* Creplin (a synonym of *L. simplicissima*) and *L. digramma* Creplin.

It is proposed by Donnadieu (1877) to unite all the species of Ligulæ in one and the same species, in the genus *Dibothrium* with the specific name *Dibothrium ligula*.

I agree with Dr. F. Zschokke (*Recherches sur l'Organisation et la Distribution Zoologique des vers Parasites des Poissons D'Eau Douce*, 1884), that the generic characters of *Ligula* are identical with those of *Dibothrium*. With regard to Donnadieu's proposed union of the different species, to which proposition Zschokke assents, I am not prepared to express an opinion, my investigations having been limited to the forms which furnish the subject matter of this paper. While the species which I have for convenience named *L. catostomi* appears to be identical with *L. simplicissima*, the other, *Dibothrium cordiceps* Leidy, presents some striking differences.

Although these entozoa are in all probability larvæ of *Dibothria*, the name *Ligula* has been in use so long that I deem it best for the present to retain it for the sucker parasite as a designation of this particular form of Dibothrium larva.

Ligula catostomi.

[Pl. XXIII, Figs. 1–5; Pl. XXIV, Figs. 1–6; Pl. XXV, Fig. 1.]

(*Dibothrium ligula* Donnadieu ?)
Ligula simplicissima Rudolphi.
Ligula monogramma Creplin.

Upon opening the body of one of the infested suckers the cavity is found to be almost completely filled with the contained parasite or parasites (plate XXIII, fig. 1). The presence of the parasite is indicated before the body is opened by the somewhat swollen condition of the abdomen. In some cases the abdominal cavity was found to be so packed with these worms that the heart, stomach, liver, and spleen were crowded into a very small space in the antero-dorsal part of the cavity, while the intestine was intertwined with the body or bodies of the parasites.

The parasites are not covered by any special cyst or membrane, but lie free in the body cavity. Usually but a single worm occurs in the host, but in one instance three were found in the abdominal cavity of a single sucker. The specimens, while presenting some differences in size, agree in their general form and outline, as well as in the details of their very simple superficial structure. They all evidently belong to the same species. On account of the extreme simplicity of structure, however, it is very difficult to determine their exact specific relation to European forms. Since the *Ligulæ* attain their sexually mature state in the intestines of certain piscivorous birds it follows that this species should have a wide geographical distribution.

The sketches which accompany these notes show sufficiently well the external character of this parasite. In general outline they are strap-shaped, attaining their greatest breadth a short distance back of the anterior end, from which point they taper slightly towards the anterior end, and gradually towards the posterior end. The anterior end is usually broad and bluntly rounded; in one case, however, it was observed to be slightly appressed into a short, blunt, subcylindrical termination (plate XXIII, fig. 5). At the extreme anterior tip there is usually a median longitudinal sulcus extending back a short distance on each lateral face. This appears, in section, to be the beginning of the adult bothrial depressions (plate XXIV, fig. 1). From about the anterior third or a little forward of that point, the body tapers slowly but rather uniformly to the posterior end, which terminates at last somewhat abruptly in a rather sharp point. The surface of the body appears to the naked eye to be smooth or nearly so, but with the aid of a simple lens it is seen to be crossed by fine transverse grooves and wrinkles. The grooves or striæ are shallow and do not divide the body into segments. They

may be regarded, however, as the first indications of the strobile condition, in which the segments are but little individualized. Usually there are a few lateral longitudinal striæ, and invariably a rather strongly marked median furrow, which begins a short distance behind the anterior end and extends almost to the posterior end, becoming more evident in the median and postero-median regions of the body. When magnified a few diameters this median line appears to be made up of a row of punctate depressions, very near together, but approximating a zigzag line, indicating what is shown more plainly, in sections, that the reproductive openings are arranged, in the adult, along the median lateral line.

The largest specimen measured 28.5 centimeters in length. At the anterior end it was 8 millimeters broad; 7 millimeters back of the anterior end the breadth was 11 millimeters; near the anterior end the breadth was 1.5 millimeters. The thickness throughout was about 2 millimeters.

Another specimen had the following dimensions: Length, 19.3 centimeters; diameter of compressed head, 2.5 millimeters; breadth near anterior end, 6 millimeters; greatest breadth, 70 millimeters from the anterior end, 9.5 millimeters; breadth near posterior end, 2 millimeters, tapering thence to a point; thickness about 2 millimeters.

Three specimens from a single host were 120, 110, and 106 millimeters in length, respectively. The breadth near the anterior end of each was 4 millimeters; the greatest breadth of No. 1 and No. 2 was 8 millimeters; of No. 3, 6 millimeters; the breadth of each near the posterior end was 1.5 millimeters. In No. 1 the greatest breadth was about 27 millimeters from the anterior end; in Nos. 2 and 3 it was about 15 millimeters from the anterior end.

The specimen mentioned above which measured 19.5 centimeters in length came from a fish which measured 11 centimeters in length, exclusive of the tail-fin. Since it was not possible to straighten the worm without breaking it, and since the alcohol had doubtless caused it to contract more or less, the length obtained by measuring the alcoholic specimen is certainly less than that of the living specimen. The weight of the host was in this instance 20.7 grams; the weight of the parasite was 2.65 grams, or about $12\frac{3}{4}$ per cent. of that of the host.

In a small sucker, 9.5 centimeters in length, exclusive of the caudal fin, three parasites were found, the measurements of which are given above. The weight of the host was 9.1 grams, while the combined weight of the three parasites was 2.5 grams, or nearly $27\frac{1}{2}$ per cent. of the weight of the host. Or, to make a parallel case, in order to infest a man weighing 180 pounds to an equal degree it would require nearly 50 pounds of tape worm.

Among the specimens which had been separated from their respective hosts before coming into my possession I find one that is quite different in shape from the others. It is 40.5 millimeters long and 10.5 millimeters broad and terminates bluntly at each end. It is probably the anterior end of a large specimen which has been broken while living so as to allow the muscles to contract strongly and obscure the broken part.

Anatomy.—On account of the few external characters of which use can be made in the identification of these specimens, it became necessary to make some investigation into the histological structure. In these investigations portions were stained with harmatoxylon, borax carmine, Bismark brown, etc. The most uniformly satisfactory results were obtained with borax carmine, Grenacher's formula, 35 per cent. alcohol.

The specimens had been lying in alcohol about three months. They had not been especially prepared for histological study, and it is probable, therefore, that many interesting features in the finer anatomy have not been brought out in my researches. All the descriptions of histological structure in this paper, as well as the sketches which are appended, are based on the carmine preparations.

Musculature and body-layers.—The layers of the anterior region of the body, where they are unmodified by the incipient genitalia, have the following arrangement: There is first a thin outer cuticular layer. This is structureless, but appears to be continuous within, with a series of longitudinal muscles. The latter, in transverse sections, present the appearance of radial plates, attached to the outer cuticular layer (plate XXIV, fig. 6). The interstices between the plates of longitudinal muscles are filled with a granular or nuclear protoplasm which is strongly stained. Towards the inner portion of this granulo-fibrillar layer there are numerous calcareous bodies. Next within the granulo-fibrillar layer is a porous or vascular layer, in which a few fine connective fibers and protoplasm, with abundant nuclei, can be distinguished. The loose, open character of this layer is due to the numerous peripheral vessels of the vascular system (plate XXIV, fig. 6, *f*). Next is a thick layer of strong, longitudinal muscles. In transverse sections the bundles of fibers of this layer are seen to be separated by plates of radial fibers, which cross from one lateral face of the body to the other, being reduced to very fine fibers in the peripheral regions, except in the subcuticular layer, where the plates of longitudinal muscles are probably derived from them. In longitudinal sections, parallel to the lateral faces, the radial plates appear as short connecting bands between the bundles of longitudinal fibers (plate XXIV, fig. 5). There are very few calcareous bodies and little or no granular protoplasm in the layer of longitudinal muscles. Next is a layer of coarse, strong, circular muscles or, more properly speaking, fibers running transversely from margin to margin, and surrounding a central space, which represents, in transverse sections, a central core of the body. The layer of circular fibers is crossed, like the longitudinal layer, by radial fibers, which in the inner parts of the layer are distinct, but in the outer portion begin to be collected into bundles, which, in turn, become the radial plates of the longitudinal layer. In the outer part of the circular layer, where the radial fibers are collecting into bundles, transverse sections show a reticulated structure, made by the crossing of the radial bundles and the circular fibers, which here also form bundles. In the meshes of the net-work thus formed are a few longitudinal fibers. Calcareous bodies are sparsely scattered through this layer, while nuclei are somewhat abundant. The inner core is crossed by numerous parallel fibers, running from side to side of the body, and which are continuous with the radial fibers of the circular and longitudinal layers. In the anterior part of the body these fibers predominate, but in the median and postero-median regions of the body they become much attenuated and scattered. There are also a few fine fibers transverse to these, *i. e.*, running from margin to margin. The inner core, in the anterior part of the body, is thickly beset with calcareous bodies, and contains very numerous nuclei.

In the above description regard is had mainly to the arrangement of layers as they occur in the anterior regions of the body. In sections made from portions taken from near the posterior end the different layers will be found to have undergone much modification, although the general distinctive character of each remains. The radial fibers, or, better, those which are parallel with the smaller diameter of the elliptical cross-

sections, suffer most change, being reduced to slender filaments. Their substance in the inner core is plainly lost to the genitalia which are already taking shape.

Vascular system.—The vascular system is represented by two sets of vessels which may, for convenience, be designated (1) peripheral, and (2) central or centro-marginal.

The peripheral vessels constitute a net-work of vessels which lies in what was called above the porous or vascular layer, between the subcuticular granular layer and the inner longitudinal layer. In this set of vessels there are a great many longitudinal vessels with numerous anastomosing branches. In both longitudinal and transverse sections many branches were seen to leave the peripheral layer, and penetrating the longitudinal muscle layer debouched into one of the longitudinal central vessels of the inner core. Near the anterior end of the body the peripheral vessels are most numerous, forming there an intricate net-work. Towards the middle of the body they become reduced in number, and assume more the character of longitudinal vessels. This character is retained near the posterior end, where the number of these vessels shown in transverse sections along each lateral border of a section is five or six. In some of the first sections of the anterior end the peripheral vessels were seen spread over the central part of the sections, showing that the vascular layer closes in the anterior end of the body along with the cuticular and subcuticular layers (plate XXIV, fig. 1). Their disposition at the extreme posterior end was not made out.

The second set of vessels are the usual centro-marginal vessels peculiar to the cestods. Of these there are two sorts, corresponding to what may be seen in adult *Dibothria*. In brief, these two sorts may be characterized as follows: The first sort consists of two conspicuous vessels, one lying towards each margin, without proper walls, excepting a few circular fibers and numerous nuclei, the lumen being filled with spongy tissue, which does not stain strongly with carmine, but contains a few nuclei, similar to those which surround the vessels (plate XXIV, fig. 2, *a d*). The second sort consists of a varying number of vessels more numerous towards the anterior end, with proper walls and an open lumen (plate XXIV, fig. 2, *b*).

I shall, for convenience, speak of the former as the marginal canals, and the latter as the aquiferous vessels.

The *marginal canals* make their appearance in sections, made very near the anterior end, as two nearly circular spots of spongy or areolar unstained or slightly stained tissue near the center of the sections. A line joining their centers corresponds with a line drawn from margin to margin. They lie directly between the lateral notches which mark the rudimentary bothria. At first they almost coincide, so that they appear to communicate. They soon separate, however, as they are traced posteriorly, and at a distance of 2 or 3 millimeters from the anterior end they are situated at about the same distance from the margins as they are from each other. Near the middle of the body they are relatively nearer the margins, the distance from one canal to the other being about one and two-thirds times the distance from a canal to the nearest margin. Towards the posterior end they approach relatively nearer the margins. These canals preserve their distinctive character throughout their whole extent. They do not in any way resemble the aquiferous vessels. Instead of being hollow tubes, as is the case with the latter, they are filled with a spongy connective tissue, which is very slightly affected by carmine staining. They are nearly circular in outline, and are limited by a few circular fibers in which there are numerous nuclei, in some of

which a nucleolus was differentiated by the staining fluid. Nuclei of the same nature, especially near the anterior end, were also seen sparsely scattered through the spongy tissue. In a few cases some irregular patches of granular protoplasm were observable among the spongy connective tissue. No branches were certainly made out leading either to or from the marginal canals. The marginal canals are throughout much larger than the aquiferous vessels. Their diameter is from .06^{mm} to .08^{mm} in the anterior and median regions of the body; towards the posterior end, however, they become somewhat smaller.

These canals are evidently the *lateral canals* of Duchamp, and the *plasmatic vessels* of Kuchenmeister and Zurn.

The *aquiferous vessels* in transverse sections of the anterior portion of the body appear to be of variable number owing to the fact that branches from the peripheral vessels join them at frequent intervals. The branches usually unite with the central vessels at an acute angle so that the cut ends of the branches cannot be distinguished from the cut ends of the main central vessels.

Near the anterior end there are eight principal vessels lying in two groups of four each, central to what I have designated the marginal canals. This disposition is not invariable, for in many sections more than four aquiferous vessels may be seen in the vicinity of one of the marginal canals.

Cross-sections of these vessels made near the anterior end of the body were oval in outline with the longer diameters varying from .014 to .03 millimeters and the shorter diameters from .01 to .014 millimeters. In both longitudinal and transverse sections the appearance is that of a hollow tube with a definite wall differentiated from the surrounding parenchyma and fibrous tissue. In cross-sections, the walls appear to be structureless. The fine longitudinal and circular contractile fibers seen in the walls of the aquiferous vessels in *D. cordiceps* were not observed in any of the longitudinal sections of *L. catostomi.* The thickness of the walls is about .0025 millimeters. Reference to the measurements which I have given and to the sketches will show that the aquiferous vessels are throughout much smaller than the marginal canals. The difference between the two is perhaps best shown in longitudinal sections, where the walls of the aquiferous vessels are seen to be more or less folded, but everywhere distinct from the surrounding tissue, and the lumen free from tissue of any sort. A longitudinal section of a marginal canal, however, shows a slightly sinuous canal filled with a fine fibrous tissue, appearing irregularly striated. Both sorts of vessels are surrounded by numerous nuclei, which in the case of the canals are in part entangled in the circular fibers which limit the canals, while in the case of the aquiferous vessels they do not enter into the structure of the vessel walls.

In the median and posterior parts of the body where the genitalia have already begun to develop the aquiferous vessels appear to be reduced to two, one at a short distance from and central to each marginal canal.

The aquiferous vessels in the median region of the body were about .013 millimeters in the smaller and .019 millimeters in the greater diameter, outside measurement, and .008 millimeters by .013 millimeters inside measurement. In this region the walls of the tubes are quite sharply defined and in some cases even slightly separated from the adjoining tissue.

I have not been able to make out any communication between either the periph-

eral or the central aquiferous vessels on the one hand, and the marginal canals on the other.

Calcareous bodies.—These are numerous, especially in the anterior regions of the body. They are confined for the most part to the central core and to the peripheral region. In the latter they are nearly all found between the cuticle and the peripheral vascular layer. In the median regions of the body they have almost disappeared from all parts except the peripheral layer and there they are not abundant. In sections from the posterior parts of the body, where the reproductive organs have begun to develop they are yet more sparsely scattered and are confined almost exclusively to the peripheral region. In size these calcareous particles vary. The larger ones measure about .008 by .01 millimeters in the two diameters. Most of them are circular or oval in outline, but some are irregular. A great many of them show a concentric structure in optical section.

Reproductive organs.—In these ligulæ from the abdominal cavity of the sucker the reproductive organs have reached a comparatively advanced stage of development.

Both longitudinal and transverse sections from the middle and posterior parts of the body show clusters of nuclei which are deeply stained by carmine. These clusters lie in the inner layer of longitudinal muscle fibers, near one of the lateral faces. In longitudinal sections made parallel to the lateral faces of the body they are seen to be arranged along the median line in a somewhat zigzag row, and correspond in position to the genital openings which are also revealed in those sections which are carried through the superficial layers of one of the lateral faces. In transverse sections each of these clusters of nuclei is seen to consist of two clusters lying side by side (plate XXV, fig. 1). They are the rudimentary genital organs. The one will, in the adult, give rise to the cirrus and its pouch, and the spermatic reservoir; the other to the vagina, uterus, ovary, etc. In the peripheral region the vitellaria are plainly indicated by a nuclear layer, which is separated from the cuticle by a thin layer of longitudinal fibers and extends to the inner layer of longitudinal muscles. The nuclei which lie in the interstices of the external layer of longitudinal muscles and those which are so abundant in the vascular layer in the anterior part of the body evidently contribute to the formation of the vitellaria.

The beginning testes are plainly indicated in transverse sections of the postero-median and posterior regions of the body. These consist, in each section, of a series of a dozen or more nests of nuclei lying towards each margin, extending from near the margin towards the center a distance equal to about one-third the diameter from margin to margin (plate XXIV, fig. 3*d*). These lie in the central core. One of these nests of nuclei is shown in section, highly magnified in fig. 42, plate XXIV.

Nuclei, which in the anterior regions of the body are more or less abundantly disseminated among the muscular and fibrous layers, are, in the median and posterior regions, confined to the peripheral and central regions, where they have already begun to collect to form the genitalia. The transverse fibers which in the anterior regions are abundant and strong, especially in the central core, and circular layer, are in large measure reduced to very fine fibers in the median and posterior regions. The various tissues of the body have already in great degree been absorbed to contribute to the formation of the genitalia. The inner layer of longitudinal muscles appears to have suffered the least from absorption thus far.

LIGULA CATOSTOMI FROM STOMACH OF A TROUT.

On February 8, 1890, I received from Professor Jordan some fragments of ligulæ from the stomach of a trout (*Salmo mykiss*).

These specimens were collected July 20, 1889, at Twin Lake, Colorado.

These fragments are in six or seven pieces, but are plainly pieces of the same worm. Their combined length is about 18 centimeters, greatest breadth 1 centimeter, and maximum thickness 3½ millimeters. The ends of the fragments present a frayed appearance, the surface is broken, pitted, the cuticle removed in places, and a general look of incipient disintegration, from which I infer that the specimen has been taken into the stomach of the trout along with its proper intermediate host. It is without doubt identical with *Ligula catostomi.* The shape, transverse striæ, and longitudinal furrows, with the profound median lateral furrow, all point conclusively to this identification. Neither the anterior nor the posterior end remains intact, and I find from superficial examination no evidence of any further approach to the adult condition than maintains in the specimens from the abdominal cavity of the sucker.

There can be but little doubt therefore that *Salmo mykiss* is not the proper host of the adult stage of this worm.

Further examination of the entozoa of the fish, and also of the piscivorous birds of the Yellowstone region will doubtless yield the necessary material for completing the history of this parasite.

Dibothrium cordiceps Leidy.*

[Pl. XXV, Figs. 2–5, Pl. XXVI, Figs. 1–5, Pl. XXVII, Fig. 5.]

These ligulæ of the trout (*Salmo mykiss*) were found, not free in the abodominal cavity, as was the case in those from the sucker, but were inclosed in the muscular walls of the abdomen. The specimens were collected in the Yellowstone River, just below the lake, October 10, 1889.

Smaller forms, apparently of the same species, were found encysted among the pyloric cœca, in the liver and in the serous covering of the stomach and intestine. These are described below. The specimens from the abdominal walls were in cavities lined with connective tissue, the cavities being from 1 to 3 centimeters in diameter.

Two trout sent by Dr. Jordan were examined. Each of these had a worm inclosed in the muscular walls of the abdomen. In one the worm was situated about 2½ centimeters in front of the ventral fin. It lay amid the muscles, but had displaced those lying immediately above and below, so that it lay contiguous to the peritoneum and was separated from the skin by a thin layer of fatty tissue. In a piece of the abdominal wall of another trout, the ligula lay in an elongated and somewhat irregular cavity tunneled out of the tissues, in all some 3 centimeters in length. The cavity in both cases was lined with connective tissue (plate XXV, fig. 5).

These specimens are very much crumpled and folded on account of having been hardened in alcohol while still confined in the narrow limits of their cysts. It is therefore difficult to obtain good measurements of them. One of the longest was measured after it had been straightened out as well as could be done in its crumpled condition. It was 15 centimeters in length. The diameter of the cylindrical anterior end was about 1 millimeter near the end, whence it tapers to a blunt point. The greatest

* Hayden's report of U. S. Geological Survey for 1871, pp. 301–2.

breadth was 3 millimeters; the thickness about 1.25 millimeters. The posterior extremity of this specimen was truncate and slightly emarginate, and about 2 millimeters broad. Anteriorly the body is somewhat tapering, rather cylindrical, and extremely irregular in outline. The body is crossed by fine transverse striæ which appear to be incipient joints. Towards the posterior and larger end these striæ become more distinct and therefore the body there assumes a decidedly segmented appearance.

Anatomy.—The following remarks on the anatomy and the sketches are based on sections of portions stained in toto in borax carmine.

Musculature.—The musculature is very similar to that of *L. catostomi.*

The layers of the body from without inward are, first a cuticular layer; next a layer of longitudinal and radial fibers with much granulo-nuclear protoplasm interspersed; next a vascular layer in which the peripheral system of aquiferous vessels is well represented along with many nuclei and, in the antero-median and median parts of the body, numerous calcareous bodies. This layer merges into a granulo-nuclear layer within, and is succeeded next by a prominent layer of longitudinal muscles. The latter is separated from the inner core by a narrow layer of circular or transverse muscles. No definite system of muscle fibers was made out in the inner core in median section; anteriorly the arrangement is like that of *L. catostomi.* The parenchyma there shows an irregular net-work of connective fibers, with numerous nuclei and immense numbers of calcareous bodies interspersed. In the near vicinity of the marginal canals and around the aquiferous vessels nuclei are very abundant. Sections of the anterior end show the presence of the two opposite bothrial pits, characteristic of the genus *Dibothrium* (plate XXV, fig. 2, *e*).

Vascular system.—This, with the exception of a feature to be mentioned presently, appears to be much like that of *L. catostomi.* In sections of the anterior end several small vessels were observed in the peripheral region. These became even more prominent in sections farther back.

The *marginal canals* soon make their appearance. As in *L. catostomi*, they are larger than the central aquiferous vessels, do not have a distinct wall, and the lumen, instead of being open, is filled with pale, unstained, spongy connective tissue, appearing somewhat fibrous in longitudinal sections. They are densely surrounded by nuclei. Near the anterior end the transverse section of one was .05 by .03 millimeter in its two diameters. A few sections of the head were characterized by a distinct line of nuclei connecting the two marginal canals (plate XXV, fig. 2, *d*). The marginal canals retain their distinctive character to the posterior end. In longitudinal sections they are seen to pursue a gently undulating course.

The *aquiferous vessels* of the inner core appear in sections near the anterior end as two principal vessels which lie near the central border of the marginal canals. As in *L. catostomi*, these vessels have a distinct wall and an open lumen. One of these vessels, in the same section from which the diameters of the marginal canal given above were obtained, measured .019 millimeter in its outer and .011 millimeter in its inner diameter. The walls of the aquiferous vessels are quite distinct from the surrounding tissue and present on the outer surface, in cross-sections, a peculiar roughened appearance, as if thickly beset with minute bristles. The inner surface of the wall appears smooth in cross-sections. In longitudinal sections made in the postero-median regions of the body the aquiferous vessels were seen to pursue a somewhat tortuous course, and their folded and crumpled walls cut through looked like a series of frills or ruffles.

Fine longitudinal and circular contractile fibers were distinctly visible. (plate XXVII, fig. 5.)

Longitudinal sections of the posterior end reveal a number of rudely circular open spaces lying in the vascular layer. Some of them are lined with a layer of fibrous tissue in which are numerous nuclei. Others are without any proper lining. The sections were made parallel with the lateral faces of the specimen. Approaching from one end of the series the sections contain from two to four of these cavities lying near the extreme tip of the posterior end and giving rise to an open, porous structure. The longitudinal vessels appear to connect with them, as do also the vessels of the peripheral layer, of which they appear to be enlargements. In sections approaching from the opposite direction there were two elliptical spaces, the long axes of which are parallel with the long axis of the body. One of these is shown highly magnified in plate XXVI, fig. 5. These lay side by side and each appeared in about eleven of the sections. The thickness of the sections was about .015 millimeter. They were completely inclosed in the tissues of the body except at the posterior ends where each communicates with the exterior by a short passage with nuclear walls. When the sections are studied with a view to reconstructing the cavities the latter are seen to be ellipsoidal, or more properly, lenticular. These spaces have a special lining of columnar epithelium resting on a nuclear layer and surrounded by a muscular layer which is made up of the continuation of the inner layer of longitudinal muscles. The latter layer also contains numerous nuclei. The maximum length of these spaces is .28 millimeter, the breadth .20 millimeter, and the thickness (estimated) .02 millimeter. They are filled with loose, granular tissue and delicate connective fibers somewhat like the tissue which fills the marginal canals, but differing from that in that the granular material takes a good stain with carmine. There were about fifty sections made through the posterior end of the specimen. The sections of these two oval vessels did not begin nor end at the same place in the series, although in a number they occur side by side. One occupies about seventeen sections; in about half of these it is accompanied by the other.

A third vessel with the same structure, viz, thick walls of columnar tissue appears in a few of the sections near the lateral face opposite the one near which the two above-described vessels lie. It occupies about six sections, is much smaller than the others, and the walls, instead of being smooth, are much folded.

I interpret these vessels as the terminal pulsatile vessels. I was not able, from the single series of sections prepared for this preliminary report, to determine their exact relations to either the aquiferous vessels or the marginal canals.

Calcareous bodies.—These are not abundant in the extreme anterior end of the body, but soon become very abundant as one proceeds posteriorly from the head. As in *L. catostomi* they are confined mainly to the peripheral granulo-vascular layer and to the central core. In the latter they are very abundant. They are somewhat larger and present rather more irregularity in shape than do those of *L. catostomi*, and finer examples of concentric structure occur. The dimensions of one of the larger bodies were .011 millimeter and .019 millimeter in the two diameters. They are seen to be still abundant, particularly in the central core, in sections made through the posterior end.

Reproductive organs.—The reproductive organs are but slightly developed. The beginnings of the cirrus pouch and the vagina are indicated by a series of clusters of nuclei which lie along the middle line near one of the lateral faces. No other traces of genitalia were observed.

YOUNG FORMS ENCYSTED IN ABDOMINAL CAVITY.

[Pl. XXVII, Figs. 1–4 and 6.]

Larvæ of this species occur not only in the abdominal walls, but also in cysts in the peritoneum of the stomach and intestines, particularly among the pyloric cæca, occasionally in the liver and spleen. Some of the cysts in the trout submitted to me for examination contained embryos 4 centimeters and over in length. These were coiled up within the cyst in irregular folds, and in places the bodies were much constricted. One specimen whose average breadth was from 1 to 1.5 millimeters was constricted in one place to a diameter of .5 millimeter. This specimen, which was about 4 millimeters in length, was similar in general outline to the larger specimens from the abdominal wall. Like them the body was crossed with fine transverse lines.

Since these specimens frequently break at the narrow constrictions, many of the alcoholic specimens present a deceptive appearance, looking as if the larva might be a worm with a slender neck, such as may be seen in such worms as *Dibothrium rugosum*, whose anterior end is often fixed firmly in the tissues of its host and there degenerates into a slender core. Some of the cysts contained a waxy secretion with a calcareous mass at the center, but no parasite. These are evidently cases of arrested development where the tissues of the parasite have undergone degeneration. One cyst 9 millimeters long and 5 millimeters broad after the connective tissue layers had been removed, when opened revealed an embryo which measured, approximately, 2.75 centimeters in length and was 1.5 millimeters wide at the widest point. The body was extremely irregular and had several constrictions. These were most pronounced near each extremity. On each side of a constriction the body swells out abruptly, producing an effect like that of a chain of small tubers. This phenomenon is doubtless due to the fact that much of the parenchyma of the body was in a plastic condition, and when the specimen was placed in alcohol the result of the unequal contraction of different parts of the body, together with its cramped and confined condition, was to impress this characteristic outline on the parasite. A small specimen about 5 millimeters long was obtained from a cyst 7 millimeters in diameter. In the center of the cyst was an amber colored, rather hard mass, which effervesced slowly with dilute hydrochloric acid. Another specimen, 8 millimeters long, folded once on itself, completely filled its cyst. This specimen was 2 millimeters broad, posterior end truncate, slightly emarginate, anterior end bluntly rounded. In some cases the embryos were embedded in the parenchyma of the cyst. In nearly every case the embryos were associated with a comparatively large mass of the original food-stuff. The cyst is evidently a nurse or blastocyst, with an investment of connective tissue, and the embryo has developed by a process of budding within the blastocyst. The embryos are flask-shaped—larger at one end than the other—gradually tapering to the smaller end. Near the larger end they are distinctly shouldered. This character is not present when the extremity is invaginated. Beyond the shouldered part there is a somewhat narrowed prolongation with a slit on each lateral face. These slits appear to be rudimentary bothria. The cysts are, for the most part, irregularly globular or oval. One, however, was observed that was elongated; in the latter the contained embryo was straight.

Anatomy.—One blastocyst containing an arcuate embryo curved around a ball of hardened parenchyma, and two embryos which had been liberated from their blastocysts were stained with borax carmine and cut into sections.

The musculature and vascular systems are substantially the same as in the larger specimens. There is, however, an epidermal layer present (plate XXVII, fig. 6, *a*) which was absent from the larger specimens. This epidermis appears in transverse sections as a border of short, curved, hair-like processes springing from a thin basement layer, which separates easily from the cuticle. The remaining layers are much like those of the larger specimens, except that the inner circular layer and the radial fibers are not yet differentiated. The layers named from the outside toward the center are: (1) the epidermal layer, (2) a thin, structureless cuticle, (3) a narrow layer of fine longitudinal fibers, (4) a dense nuclear layer, (5) a comparatively broad layer with scattered nuclei and a few calcareous bodies, and the vessels of the peripheral system, (6) a rather narrow but very persistent and strongly marked layer of longitudinal muscles. Within the layer of longitudinal muscles there is no further differentiation into layers. In it, however, a net-work of fine connective fibers, with numerous nuclei, a few calcareous bodies, the aquiferous vessels and marginal canals, are clearly revealed in the stained sections. In some of the sections a slight tendency to parallelism in the connective fibers immediately within the layer of longitudinal muscles indicated the beginning of the layer of circular muscles which occurs at this place in the larger forms.

The marginal canals and the aquiferous vessels have essentially the same structure as the same vessels in the larger specimens.

The principal aquiferous vessel lies rather closer to the marginal canals than is the case in the larger specimens. As in the larger specimens, the marginal canals are characterized by their relatively large size, absence of proper walls, abundance of nuclei surrounding them, and a spongy, unstained interior tissue. Close to the central border of each of the marginal canals is the smaller aquiferous vessel (plate XXVII, fig. 6, *g*), with proper wall, open lumen, and in longitudinal section an irregular, crumpled, and interrupted outline marking its tortuous course. Its wall is surrounded by nuclei.

There are but few calcareous bodies in the central core. They are smaller and more uniformly elliptical in outline than those of the larger specimens. The largest measured .012 by .008 millimeter in their two optical diameters.

The blastocyst has the following structure: Its investing wall consists of a number of concentric layers, which in section appear like parallel fibers. These layers are rich in nuclei. In some of the sections in the vicinity of the embryo, these had become somewhat separated from each other, and as many as sixteen were counted. These layers appear to result from the delamination of the outer portions of the parenchyma of the blastocyst. Nuclei exist in abundance in the external portion of the mass of parenchyma on the side adjoining the embryo.

For the most part the parenchyma appears uniformly granular and non-nucleated. There is some evidence, however, of both contractile tissue and vascular structures.

Several *Nematods* from these pyloric cæca, where they were encapsuled in the serous membrane, a few also in cysts in the peritoneum, and one *Echinorhynchus* were found in these trout. It has been thought best not to include descriptions of them in this paper.

WASHINGTON, PA., *February* 27, 1890.

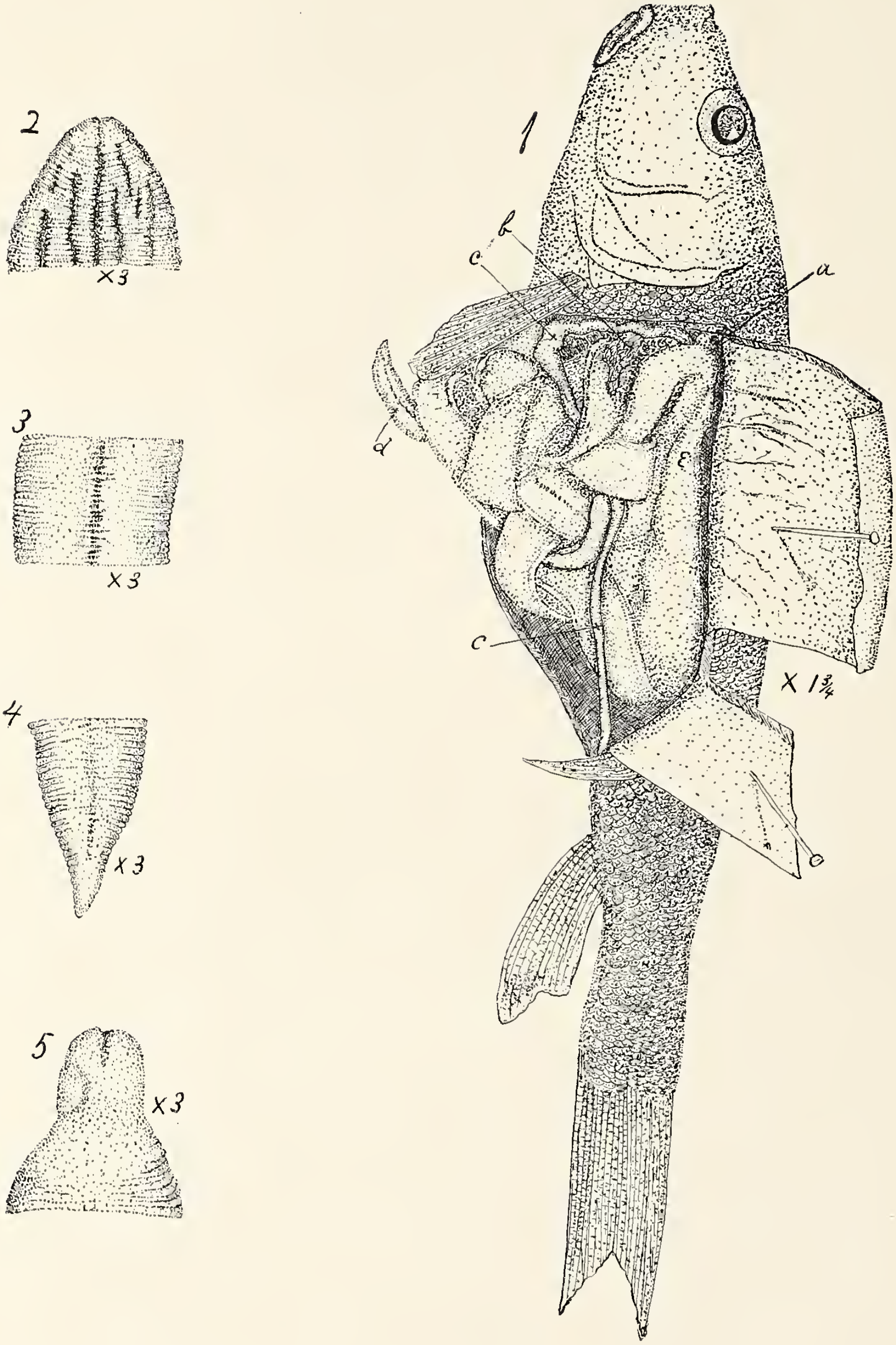

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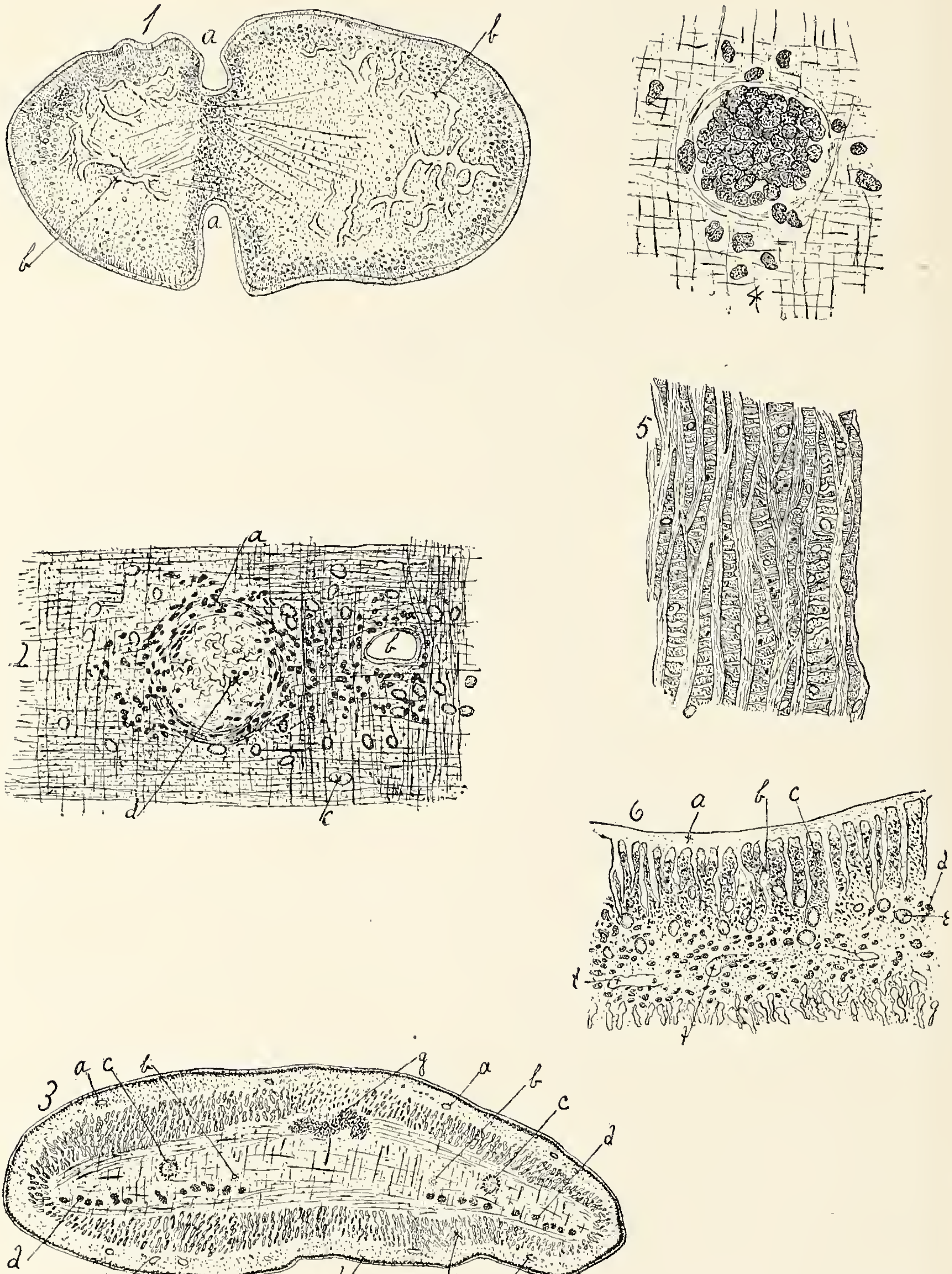
PLATE XXIV.



EXPLANATION OF PLATE XXIII.

Fig. 1. *Ligula catostomi* in abdominal cavity of sucker (*Catostomus ardens* J. & G.).

a, b. Viscera of host. The heart, liver, spleen, etc., are crowded into a very small space in the anterior dorsal part of the body cavity.

cc. Intestine of host.

d. Posterior end of Ligula.

e. Anterior end of Ligula.

Fig. 2. Anterior end of Ligula. × 3.

Fig. 3. Median region of body. × 3.

Fig. 4. Posterior end. × 3.

Fig. 5. Anterior end of another specimen. × 3.

Drawings by the author.

EXPLANATION OF PLATE XXIV.

Fig 1. *Ligula catostomi.* Transverse section near anterior end. × 60.

aa. Bothria.

bb. Peripheral aquiferous vessels.

Fig. 2. Transverse section of longitudinal vessels near anterior end. × 300.

a. Circular fibers with nuclei surrounding one of the marginal canals.

b. Lumen of aquiferous vessel.

c. Calcareous body.

d. Nuclei in spongy tissue forming lumen of marginal canal.

Fig. 3. Transverse section near posterior end of body. × 27.

aaaa. Peripheral aquiferous vessels.

bb. Central aquiferous vessels.

cc. Marginal canals.

dd. Testes.

e. Longitudinal muscle layer.

f. Subcuticular granular layer, which, when highly magnified, shows the beginning vitellaria.

g. Incipient generative organs.

Fig 4. One of the nests of nuclei forming a testicule *d* of Fig 3. × 750.

Fig. 5. Longitudinal section through longitudinal muscle layer from median region of the body, enlarged about 300 diameters. The section was made parallel to a lateral face. A few nuclei and calcareous bodies are shown. The latticed appearance of the interstitial spaces is due to the radial fibers mentioned in the text.

Fig. 6. Portion of the border of a transverse section from same region as Fig 2. Enlarged about 300 diameters.

a. Cuticle.

b. Plate of peripheral longitudinal muscle layer.

c. Granular and nuclear protoplasm.

d. Nuclei of vascular layer.

e. Calcareous bodies.

ff. Peripheral aquiferous vessels.

g. Outer portion of inner longitudinal muscle layer.

Drawings by the author.

EXPLANATION OF PLATE XXV.

Fig. 1. *Ligula catostomi.* Portion of transverse section from same region as Fig. 3 of Plate 4. Enlarged about 60 diameters.

a. Cuticle.

b. Remains of external longitudinal muscle layer.

cc. Peripheral aquiferous vessels.

d. Calcareous bodies.

ee. Longitudinal muscle layer.

f. Circular layer.
g. Rudimentary male generative organs.
h. Rudimentary female generative organs.
i. Position of genital aperture.
k. Subcuticular granular layer, vitellaria.

Fig. 2. *Dibothrium cordiceps.* Transverse section near anterior end. ×75.
aaa. Peripheral aquiferous vessels.
bb. Central aquiferous vessels
cc. Marginal canals.
d. Row of nuclei connecting marginal canals.
ee. Bothria.
f. Epidermal layer.
g. Nerve cells ?

Fig. 3. Longitudinal section near margin. (The outer layer of longitudinal muscles is wanting near the margins, the space being occupied by masses of nuclei which have much the same appearance in longitudinal sections as they have in transverse sections.) × about 250 diameters.
a. Cuticle.
b. Subcuticular granulo-nuclear layer.
cc. Peripheral aquiferous vessels.
d. Calcareous body, showing concentric structure.
e. Longitudinal muscle layer.
f. Nuclei of vascular layer.

Fig. 4. Calcareous body, optical section showing concentric structure. × about 750 diameters.

Fig. 5. Portion of abdominal wall of *Salmo mykiss* with parasite inclosed. × 3.
a. Epidermis of host.
b. Muscular tissue of host.
c. Connective tissue layer of cavity in which the parasite lies.
d. Posterior end of parasite.
e. Anterior end of same.

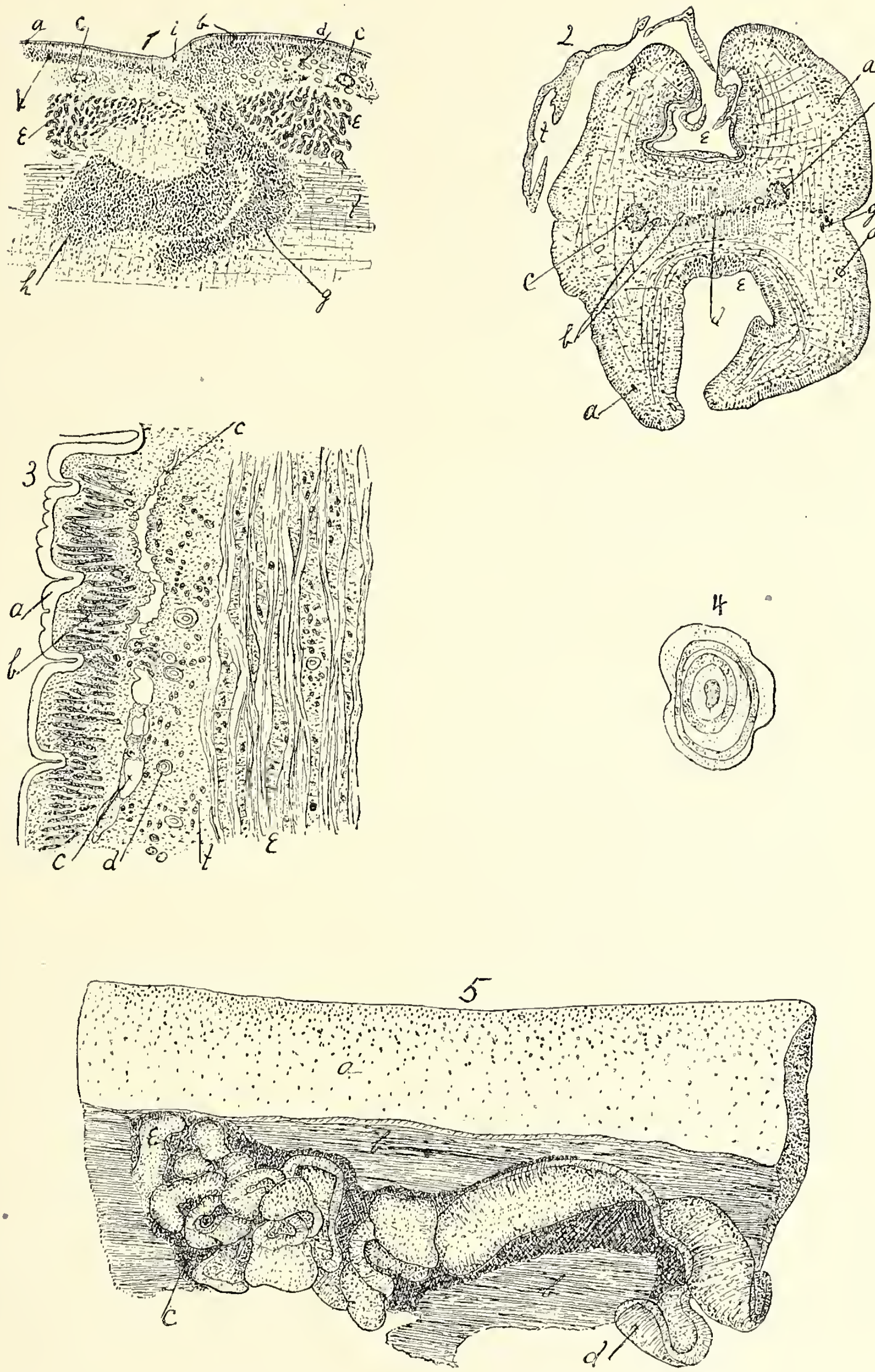
Drawings by the author.

EXPLANATION OF PLATE XXVI.

Fig. 1. *Dibothrium cordiceps,* anterior end.
Fig. 2. Middle.
Fig. 3. Posterior end. Figs. 1–3, × 6.
Fig. 4. Transverse section of longitudinal vessels, near anterior end. × about 200 diameters.
aa. Cut end of longitudinal muscles.
bb. Circular muscles.
cc. Calcareous bodies.
c′c′. Same in optical section, showing concentric structure.
d. Marginal canal.
e. Central aquiferous vessel.

Fig. 5. Longitudinal section of pulsatile vessel posterior end. × about 200 diameters.
a. Layer of columnar epithelium.
b. Excretory pore.
c. Cuticle.
d. Subcuticular layer of nuclei.
e. Parenchyma with connective tissue and nuclei.
f. Nuclei of muscular layer surrounding pulsatile vessel.
f′. Granulo-nuclear layer supporting columnar epithelial layer.
gg. Longitudinal muscle fibers.
h. Cluster of nuclei marking first appearance of second pulsatile vessel.

Drawings by the author.

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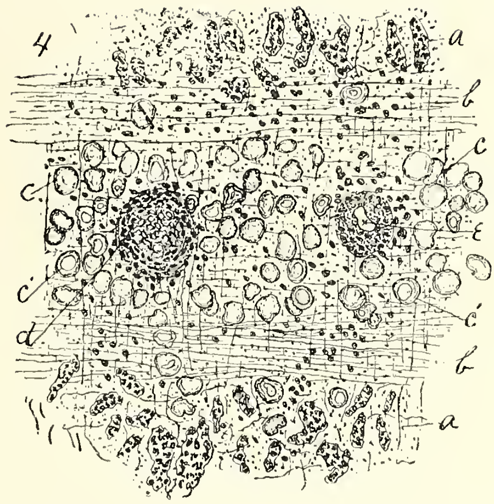
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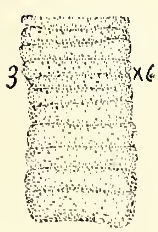
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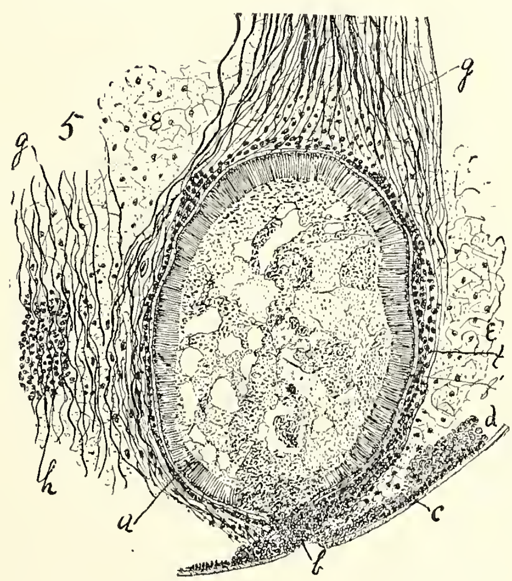
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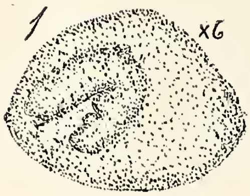

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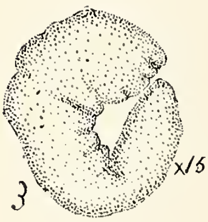

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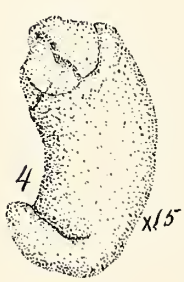

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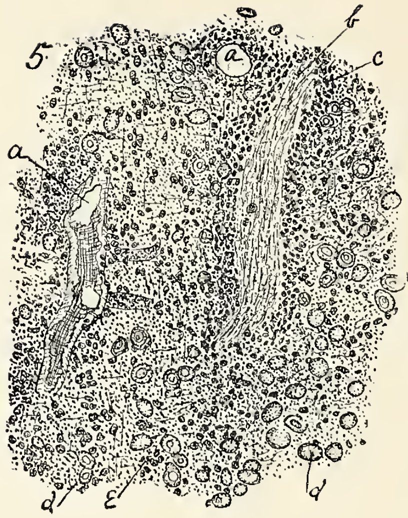

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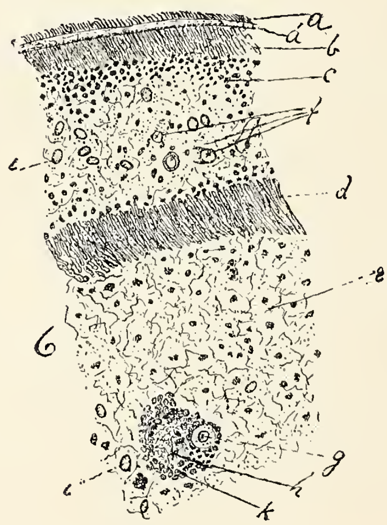


EXPLANATION OF PLATE XXVII.

Fig. 1. Cyst containing embryo from pyloric cæca of *Salmo mykiss*. × 6.

Figs. 2, 3, 4. Embryos liberated from their cysts. × 15.

Fig. 5. Longitudinal section of longitudinal vessels of specimen from abdominal walls of host; sections from same region of body as that of Fig. 4, Pl. IV. × about 300.

aa. Spaces where aquiferous vessel is cut through; the essel is seen to have both longitudinal and circular muscle fibers in its walls.

b. Lumen of marginal canal; the spongy tissue which fills it has a striated appearance in longitudinal section.

c. Nuclei.

dd. Calcareous bodies.

Fig. 6. Part of transverse section of embryo from cyst in pyloric cæca, highly magnified.

a. Epidermis.

a'. Cuticle.

b. External layer of longitudinal muscles.

c. Nuclei.

d. Inner layer of longitudinal muscles.

e. Parenchyma, with connective tissue fibers and nuclei.

f. Peripheral aquiferous vessels.

g. Central aquiferous vessel.

h. Marginal canal.

ii. Calcareous bodies.

k. Nuclei surrounding marginal vessel.

Drawings by the author.

4.—THE ARTIFICIAL PROPAGATION OF STURGEON IN SCHLESWIG-HOLSTEIN, GERMANY.*

EXPERIMENTS ON THE RIVER STÖR IN 1877.

[From the "Itzehoer Nachrichten," No. 87, Itzehoe, July 31, 1887.]

This new and interesting branch of fish-culture has repeatedly been tried in Europe, but so far without favorable results. An attempt made in America two years ago, however, to hatch sturgeon eggs by artificial means proved successful. Mr. Seth Green and Mr. A. Marks of the New York State fish commission caught a male and female sturgeon at the mouth of Wappinger's Creek near New Hamburgh [on the Hudson River] and succeeded in impregnating the eggs of the latter with the milt taken from the male fish. From the eggs fertilized on June 7, about 40,000 sturgeon were hatched on the 10th and 11th. Another trial made June 12 also proved successful. Mr. Marks then took five pans of eggs, and about one hundred hours subsequent to impregnation in the neighborhood of 60,000 young sturgeon were hatched, the temperature of the water being from 67° to 74° Fahrenheit.

Having learned of these successful experiments, the board of directors of the Itzehoe Sturgeon Fishery Association, which is presided over by Mr. Dohrn, the mayor of Itzehoe, resolved to make an attempt to propagate the sturgeon artificially in their waters.

July 2, two fishermen, J. Trede and Kappelan, captured a male and a female sturgeon; on the following day the roe was taken from the spawner and after being impregnated with the milt was put in hatching boxes. At the end of eighty hours the embryos had so far developed that they could be seen in the eggs, but on account of the great change in the temperature of the water the eggs had been injured, so that the embryos, which in the evening had a clear bluish-gray color, assumed a yellowish tint the next morning resembling that of a decayed fish. From that time on the eggs presented a bad appearance and gradually decayed, the experiment, therefore, terminating unfavorably.

Nevertheless, a second trial was soon after made. In the morning of July 15, a female sturgeon, weighing about 150 pounds, was caught, which, when taken from the water, began to emit its roe, and was therefore seen to be mature. As much of the roe as possible was gently squeezed from the fish, and the remainder taken from it by cutting. All the roe was immediately put in pans which had been half filled with water from the River Stör, and, while the roe was gently, but continuously, stirred, the milt of a male sturgeon, weighing about 50 pounds, was slowly poured over it. The milt was obtained by removing the testes from the male fish and subjecting them to pressure. After the roe had been impregnated, the stirring was continued for half an hour, and the water in the pans frequently renewed, in order to

* Reports translated from the German by Herman Jacobson.

diminish somewhat the large and constantly increasing quantity of viscid slime. At 10.30 a. m. the fertilized eggs were transferred to hatching-boxes, four of which were placed in the River Stör, where there was a moderately strong current, and where the temperature of the water was about 17° Réaumur. One hatching-box, containing a small quantity of eggs, was moored in a ditch containing water at a temperature of 18° Réaumur. The several hatching-boxes in the River Stör were supplied with different quantities of eggs in order to determine how many could best be kept together.

The formation of the embryos in the eggs could be seen distinctly with the aid of a magnifying glass at 8 p. m., July 17. At 9 a. m. on the 18th, the embryos were observed to be moving about in the eggs, and at 1 p. m., of the same day, the tails of several protruded from the eggs and were actively in motion, although the head was still within the egg. On the evening of this day the embryos could be numbered by the thousands.

On the morning of July 18, the live ones were removed to another empty hatching-box, which, like the former boxes, was floated in a moderately strong current. On the morning of July 19, about 9 o'clock, a good many little fish had entirely released their heads, and were swimming about in the box, the egg still forming the central part of the body. From that time on the egg gradually changed, the central portion of the body of the embryo still developing within it, until it disappeared almost entirely, and was hanging from the lower side of the fish, being reduced in size to that of a grain of mustard. July 23, the young fish were completely developed; and on the 25th two-thirds of them, about 50,000 to 60,000 in number, were conveyed from Beidenfleth to Itzehoe, and placed in the River Stör. The remaining one-third was retained in the hatching-box at Beidenfleth, in order to observe the further growth of the young fish.

It appears, from this experiment, that seventy-two hours after impregnation the embryo can be seen in the egg; that the tail portion is released seventy-eight hours after impregnation; the head one hundred hours after, and that two hundred hours after impregnation the young fish are so far advanced that they can be set free in open water.

REPORT OF OPERATIONS DURING 1885.*

[From "Ninth Annual Report of the Central Fishery Association of Schleswig-Holstein" Rendsburg, 1886.]

In the year 1885 our association received 500 marks [$119] for the purpose of aiding our efforts in sturgeon-culture; and the board of directors promised to do every thing in its power to that end. The writer was commissioned to take charge of this work, and in the spring went to Hamburg for the purpose of arranging with the owners of the large sturgeon establishments on the Elbe, to supply the sturgeon necessary for obtaining the roe and milt, which all of them promised to do. I next visited Twielenfleth, Kollmar and Glückstadt, in order to secure the services of two men to take charge of the proposed sturgeon-hatching. In Twielenfleth I found Mr. Köser, and in Kollmar Mr. Lau, both of whom expressed a great interest in the matter, and would

*By B. Elsner.

gladly undertake the new charge. Mr. Mohr in Glückstadt had assisted in the similar experiments of 1884, and promised to take part in those now proposed. Besides the above Mr. Söth, a fisherman of Tielenhemme, was commissioned to superintend a sturgeon hatchery on the River Eider. All of these persons displayed great activity in their work. Several lots of eggs were fertilized at different times, but, unfortunately, not with successful results, as it was only on rare occasions that mature spawners and milters could be obtained at the same time; and if a ripe male was secured from the nearest fishing station, the female frequently died in the mean time. Mr. Lau at Kollmar alone succeeded in hatching a comparatively small number of sturgeon, which developed in healthy condition, and were planted in the River Elbe.

It will be claimed by some, perhaps, that the same methods could be pursued with the sturgeon as with the salmon, viz, to catch the males and females, and hold them until the spawning season. This has been attempted but without favorable result. We had a large box made and placed in the harbor of Glückstadt,-at the mouth of the river Riehn, and put sturgeon in it, with the view of keeping them until the spawning season. But the sturgeon would live in this box only a comparatively short time. This may result from the fact that the hatching season of the sturgeon is in warm weather, chiefly during the month of July, when the temperature of the water is about 17° Réaumur. The large fish also become injured in the box. Not only did we attempt to keep sturgeon in this way, but we also tried to confine them alive in a pond near Glückstadt, through which fresh water from the Elbe flows at every tide. Even in this pond, however, the sturgeon died after a few days.

As far as I have been able to observe, the greatest difficulty in the way of sturgeon culture results from the fact that the spawners, when mature, emit the eggs within a very short space of time. When a mature spawner has been caught, the roe commences to run as soon as the fishermen lift the fish into the boat, and it continues to flow while it is being conveyed to the station where its fertilization is to be effected. In case the fishermen tie up the ovarian duct so that the roe can not escape before the fish reaches the hatching station, the impregnation of the eggs can be accomplished successfully, providing a good milter is on hand. If, however, this is not the case, and the spawner has to lie for ten hours before a milter is obtained from the nearest fishing station, the roe inside the fish becomes so soft that many of the eggs break during the process of impregnation. If a mature fish is thus compelled to retain the roe for any length of time, the eggs become quite transparent, and fall to pieces when touched.

During the present year (1886) the attendants at Glückstadt have succeeded five times, and Mr. Lau, at Kollmar, twice, in hatching sturgeon. Considering the failures of former years, these results must be regarded as exceedingly favorable, but we are still far from having reached a point where we can say that the greatest difficulties in sturgeon hatching have now been overcome. There is, as yet, no absolute certainty about the matter, and a great deal depends upon contingencies.

If sturgeon culture is to be made of economical importance, it is absolutely necessary that we should produce several million young every year. By the occasional hatching of a few thousand sturgeon only we can not say that we materially aid in the increase of the abundance of the species. This has been my view of the case for some time, and it was confirmed when I visited Glückstadt in July, in order to plant in the river Elbe the sturgeon that had been hatched at that station. Some experiments

were made for me with the view of ascertaining the number of sturgeon eggs to a pound. For this purpose a quantity of eggs was carefully weighed and it was found that 68,888 were required to make a pound. Last summer a fisherman brought to Glückstadt a mature sturgeon which was estimated to contain eighty pounds of roe. If the roe of such a sturgeon were successfully treated, we would get 5,511,040 impregnated eggs. I think that this goes to prove that if we desire to aid nature we must hatch sturgeon by the million. But in order to do this, it is necessary to gain much more experience than we now have in regard to the matter. In the first place, it is essential that we should make every possible effort to devise some means of penning sturgeon, which have not been much injured during capture, until they become mature. I would like to see the German Fishery Association grant to our association a certain sum annually for this purpose for a period of ten years, for if we desire to hatch sturgeon successfully, we must arrive at something definite in the matter, so that it can be said when there have been average catches, we are prepared to impregnate a specific number of sturgeon eggs. It is also very desirable that the Seth Green hatching apparatus, now in use, should be slightly modified by replacing the wooden front and back with metal wire grating from 3 to 4 inches high, so that when the apparatus is placed where there is not much current, the tide may nevertheless pass through it. At present the water must be kept in continuous gentle motion in order to insure a slight current through the apparatus. This motion is effected by means of a boat or raft producing gentle waves which pass through the grating from below. The present apparatus is serviceable in the open waters of the Elbe, where the surface, however, sometimes becomes so rough that no boats will venture out from the secure harbor; but if some other arrangement were possible, one would not think of resorting to such a place. If the Seth Green hatching apparatus were changed, in the manner indicated above, it could, in order to adapt it to occasional spells of rough water, easily be altered so as to cause the waves to pass through the grating from below only, by putting boards in front of the grating.

It is exceedingly desirable to hatch large numbers of sturgeon, because the sturgeon fisheries are constantly declining. The sturgeon fishermen on the Elbe take a lively interest in the subject of sturgeon-culture. This is evident from the fact that the Holstein fishermen of the Lower Elbe and of the rivers Stör, Krückan, and Riehn have formed an association, the by-laws of which contain the following provision: "This association considers it as its object to increase the quantity of fish within its territory by planting artificially raised fish in such places as are suited to them. Every mature spawning sturgeon caught by a member of the association shall, for that purpose, be delivered at the nearest hatching station (mouth of the river Stör, Glückstadt, or Kollmar.)" Furthermore, "every member of the association is obliged to set free at once any sturgeon caught by him which does not measure at least 1.25 meters in length," and "only such nets are to be used for catching sturgeon as have the meshes, when wet, at least 16 centimeters across from knot to knot, and therefore measuring at least 64 centimeters in circumference." It appears from the above that our practical fishermen are anxious to protect and increase the sturgeon, and that the old adage, "Fishermen only want to destroy," does not apply to them, for the minimum length of sturgeon allowed by law to be taken is only one meter. I am fully convinced that if our fishermen are given some practical hints by persons who have a thorough knowledge of the fisheries, they will gladly do their share in aiding us to further the interests of the same.

REPORTS OF OPERATIONS DURING 1886.

[From Circular No. 4, 1886, of the German Fishery Association, Berlin, September 28, 1886.]

We are pleased to state that good news has been received relative to the artificial propagation of the sturgeon, and that the experiments made in Schleswig-Holstein have proved successful.

"How long do the young sturgeon which have been artificially hatched remain in the mouths of our rivers?" and "After how many years do these fish return from the sea to the nets of our fishermen?" These are important questions, and letters respecting that subject were addressed to Mr. von Stemann and to Dr. Pancritius. The answer received from the latter gentleman is given below. Mr. von Stemann replied to our jocular request to obtain for us, in 1887, 10,000,000 young sturgeon, as follows: "This year has greatly encouraged us, and we shall surely reach the desired 10,000,000 young sturgeon in 1887." He continues: "As far as could be observed during the experiments in sturgeon culture made in 1879 at Frauen-Beidenfleth, the young sturgeon remain in the mouths of the rivers. During the years 1882 and 1883 many sturgeon measuring half a meter in length were observed and caught in the lower part of the river Stör, this being accounted for by the hatching work of 1879." An old Glückstadt sturgeon fisherman has said regarding this year's hatching, "We ought to have known this fifty years ago and we would now have plenty of sturgeon. But if people want to reap all the time without ever sowing, evil results must follow."

We are very glad to see that the Schleswig-Holstein fishermen, who for a long time have been our faithful followers and co-workers in the matter of salmon culture, have now also become enthusiastic in the cause of sturgeon culture. With respect to what is being done with reference to this species we feel that it is our first duty to use the money intrusted to us in increasing the supply of standard food products.

We give below the preliminary report of sturgeon culture made by the Central Fishery Association of Schleswig-Holstein and the letter of Dr. Pancritius.

PRELIMINARY REPORT ON STURGEON HATCHING IN 1886.

The many failures which followed the extensive experiments made in 1883, '84, and '85 to obtain, impregnate, and hatch sturgeon eggs in the Elbe and Eider had led us to discuss the question as to whether it was advisable to spend any more time and money on sturgeon culture. The strong encouragement and aid given us by the German Fishery Association overcame our scruples, however, and in the month of May, 1886, extensive and careful preparations were made for beginning a new series of experiments. Hatching apparatus was distributed, the fishermen were properly instructed, and we placed ourselves in direct relations with the sturgeon fishermen and dealers.

Many willing hands worked with us in this deserving cause, and in future special reports we intend to acknowledge our indebtedness to each of our co-workers without whose services it would have been impossible to obtain such favorable results.

On July 5 the first mature spawning sturgeon was brought to Glückstadt. A milter was in readiness, the eggs were successfully fertilized at once, and July 8 fully 200,000 young sturgeon were placed in the Elbe. July 15 another lot of eggs were fertilized, from which 50,000 embryos were obtained.

On July 16 at least 1,000,000 eggs were impregnated near Glückstadt. When the young fish had so far developed that they would have been ready for planting in the Elbe on the following day, the hatching apparatus was tossed about so violently by a rough sea that most of the young fish escaped. The remainder were liberated in the Elbe on the morning of July 21 by Mr. Elsner, but he was unable to give a detailed statement regarding the precise results of this trial. The number of fish hatched in the apparatus was estimated at 400,000. At the same time about 30,000 young sturgeon had been successfully hatched at Kollmar on the Elbe.

On July 25 and 26 all the Glückstadt apparatus was again filled with impregnated eggs, and on July 31 400,000 young sturgeon were planted in the Elbe. The last hatching of the season occurred near Glückstadt August 4, from eggs which had been impregnated on July 31, and produced about 9,000 young fish. The labors of this year may, therefore, be said to have given very favorable results, and our fish culturists have gained a great deal of experience.

In still another direction we are able to record important results, which will be explained in a full and detailed report at some future time.

In the name of the board of directors of the Central Fishery Association of Schleswig-Holstein.

VON STEMANN.
ELSNER.

LETTER OF DR. PANCRITIUS.

It gives me great pleasure to answer your questions of August 20, which I do as follows:

1. How long do the young sturgeon remain in the rivers before migrating to the sea?

It must be assumed that the sturgeon go into salt water in the beginning of the second spring, as sturgeon measuring 10 to 12 centimeters in length have been caught at sea. In the inlets and bays on our coasts many sturgeon of that size are likewise caught, and it must certainly be presumed that these fish are on their way to the sea.

2. How old are the sturgeon when they return from the sea?

Unfortunately we lack precise observations on this point, and without such data it will be absolutely impossible to answer this question. With this object in view, regular observations have, at our suggestion, been made at Neukrug (on the Baltic), and we are now looking for other suitable places where similar observations can be taken in our bays and rivers. A comparison of all these will probably furnish material for replying to this question.

3. The bulk of the sturgeon captured weigh from 25 to 35 kilograms each [55 to 77 pounds]. Are sturgeon of this weight the first to return from the open sea?

This question, like the second, can not be answered at present, as all the sturgeon on which I have had reports were caught in salt water.

4. Is it known where the sturgeon that spawn in the rivers of the Baltic live during the time they are at sea?

Our coasts furnish sufficient food for the sturgeon, and we therefore have a considerable number, though not a superabundance of them. It is probable that it might be ascertained whether these sturgeon have been hatched in the rivers on these coasts by marking some of the young fish.

We have now commenced to keep very full and careful records respecting the salmon and sturgeon, and we think that uniform and simultaneous observations of this

character made in every part of Germany would result in furnishing a tolerably correct idea of the mode of life of those species. It is necessary, however, that the stations for making observations should be carefully selected, as very erroneous results might be obtained through insufficient and inexact data. The stations should be visited from time to time by competent persons, who should personally give instructions how to conduct the observations. We are now publishing a large edition of our salmon and sturgeon record-books, and shall take the liberty to forward copies for your inspection.

Hoping that it will soon be possible to answer all of the above questions in a satisfactory and exhaustive manner, I am, very respectfully,

Your obedient servant,

Dr. PANCRITIUS.

[From Circular No. 6, 1886, of the German Fishery Association, Berlin, December 30, 1886.]

At the request of the German Fishery Association, the board of directors of the Central Fishery Association of Schleswig-Holstein has continued, in 1886, its efforts in regard to sturgeon-culture, and has attained better results than in any previous years. The work of this year was important not only on account of the many thousands of sturgeons that were hatched, but also by reason of the greater experience gained by the sturgeon fishermen. If sturgeon-culture is to be established upon a secure basis in the future, this can only be brought about through the willing and intelligent aid of the fishermen.

All that has been accomplished in the matter of sturgeon-culture, has been done in the special interest of the sturgeon fishermen, a fact which they now recognize; and in a few years we hope to be able to report that those fishermen on the Elbe and Eider have hatcheries of their own, in which, with the aid of the German Fishery Association, millions of sturgeons will be produced every year.

From the daily reports of this year's work we quote the following:

Mr. Elsner, a fish-culturist, directed the work during June, 1886, at the Elbe stations of Glückstadt, Kollmar, and Twielenfleth and on the Eider near Thielenhemme.

Hatching apparatus was supplied, and rewards of 50 marks [$11.90], 75 marks [$17.55], and 100 marks [$23.80] were offered for lots of 10,000, 20,000, and more young sturgeon hatched at these stations.

July 7 our faithful co-worker, Mr. J. Mohr, of Glückstadt, telegraphed that sturgeon had been hatched near that place. Mr. Elsner immediately went to Glückstadt and found live embryos in three of the hatching-boxes. July 8 the fish were ready for planting to the number of about 200,000. This number was calculated upon the basis of 68,888 eggs to the pound of mature roe.

Mr. Mohr reports as follows: On Saturday, July 3, about 11 o'clock a. m., Mr. Kuhnerti, a fisherman, arrived from Störort with a mature spawning sturgeon. I was immediately informed of the fact, and, in conjunction with Mr. Stepnetsch and several fishermen, commenced to impregnate the eggs. We had two mature males secured by a chain, and the milt of both of these was used in that connection. About 2 o'clock in the afternoon the work of impregnating the eggs was finished, and all the eggs were placed in three hatching-boxes. On Wednesday morning, about 8 o'clock, or ninety-three hours after impregnation, the first free embryos were observed in the apparatus, and about noon, so far as could be determined, all the eggs had been hatched. For this

first successful experiment Mr. Mohr received 100 marks [$23.80,] to be distributed among his co-workers. After news had been received from Mr. Köser at Twielenfleth that sturgeon-fishing was over for the season at that place, and that nothing had been accomplished, the hatching apparatus was sent to Glückstadt, so as to afford increased facilities at that station.

July 15, at 11.30 a. m., another mature female sturgeon was brought by Mr. Mohr, which contained fully 1 pound of ripe eggs. A milter had been kept in readiness, and the eggs were again successfully fertilized. On July 19, at 8.30 a. m., the first free embryos were observed and the remainder hatched out about noon. The number of young fish was estimated at 50,000. Meanwhile Mr. Mohr received another mature spawner at noon July 16. A ripe male was on hand, but did not yield enough milt for all the eggs. A sufficient quantity of eggs was impregnated, however, to fill four hatching-boxes at once, and about 3 o'clock in the afternoon the remaining eggs were fertilized, filling two additional boxes. Altogether at least 1,000,000 eggs were impregnated.

During the night of July 19 and 20, however, a very strong southwest wind arose producing rough water which submerged the hatching apparatus to some extent. On the morning of July 20 three of the boxes contained young sturgeon, but the bottoms of the other three had given way. The wire work in the latter had become rusted along the edges through contact with sea water, and could not withstand the force of the waves. Mr. Mohr had all the boxes conveyed to another locality, towing them slowly along, attached to the stern of a rowboat; but it was impossible to avoid losing some of the embryos during this transfer, from 20 to 30 of them being washed out by every high wave encountered. On the morning of the 21st all of the embryos that remained were set free, but their number was very small, as a large proportion had been lost in the manner described. It must be considered, however, that a great many young sturgeon actually got into the waters of the Elbe, for Mr. Mohr had observed large numbers of young fish in the apparatus that remained in good condition and in one of the boxes whose bottom had been broken he had also noticed a few embryos; but they were not planted directly by the hand of man. Mr. Mohr again received 100 marks [$23.80] for distribution among the fishermen and assistants. An old sturgeon fisherman, Friedrich Hansen, had witnessed the experiments in sturgeon hatching; and, after the first favorable results, he said: "If we had only impregnated sturgeon eggs many years ago, we would now catch more sturgeon."

In view of these words, spoken by an old and experienced sturgeon fisherman, the board of directors of the Schleswig-Holstein Fishery Association feels justified in presuming that mature spawning sturgeon are caught by the fishermen more frequently than is generally supposed. The board of directors, therefore, hopes that as soon as the fishermen of Schleswig-Holstein have been duly impressed with the great importance of artificial sturgeon-culture, the future of the sturgeon fisheries will be assured; but it should not be forgotten that this will take many years.

On July 18, at 7 p. m., a fisherman brought to Mr. J. Lau, of Kollmar, a mature spawner. A milter was immediately obtained, the eggs were fertilized and transferred to three boxes, and the latter were placed in the river Wetteree. July 19, at 7 a. m., Mr. Lau received a second mature female. A milter was also secured at once, and the eggs fertilized, but there was only one more hatching-box on hand. This was filled with eggs, and the remaining eggs were placed in the Wetteree near the apparatus, where at every tide there is a current of fresh water from the Elbe.

July 22, Mr. Lau reported that some eggs had been hatched. On the evening of July 23, Mr. Elsner returned to Glückstadt, and on the morning of the 24th, went to Kollmar, where he found young sturgeon in only two of the boxes. Mould had also formed in the apparatus to such an extent that the young fish had been affected by it, and large numbers of them died. Mr. Lau, therefore, considered it expedient to liberate the young fish on the 23d. He said that he examined the apparatus on the 22d, about 3 p. m., and found a great many free embryos in the three boxes which had first been filled, fewer in the second and none in the third. On the morning of the 23d, about 6 a. m., he also noticed young fish in the box containing eggs from the second lot; but as all the boxes contained a great amount of mould, he was obliged to plant the young fish in the river, reserving a few, however, as tangible evidence of his success.

Mr. Lau estimated that from 20,000 to 30,000 young sturgeon had been liberated in the open Elbe. He also supposes that young fish were hatched from the eggs placed in the Wetteree; but of this he is not absolutely certain. He received a reward of 100 marks.

In the afternoon of July 25, and the evening of the 26th, some more sturgeon eggs were impregnated at Glückstadt. The young fish obtained from these eggs were planted in the Elbe on July 31. Their number was estimated at 400,000.

Late at night on July 31 still another lot of eggs was impregnated at Glückstadt, and this was the sixth and last trial made for the season. During a part of this time, however, a very strong northwest wind prevailed, producing rough water, so that only a few thousand young sturgeon were hatched in one box (although three had been filled with eggs) and placed in the open Elbe on August 4.

The work of fertilizing the eggs at Glückstadt was conducted chiefly under the direction of Mr. Mohr, and the management of the hatching apparatus was likewise under his supervision. Several other persons also participated in the work and manifested a lively interest in the same. Mr. Mohr, however, deserves the principal credit for the advancement that has been made. Everybody, in fact, was interested in the matter, and both the fishermen and assistants exerted themselves, not on account of the awards which Mr. Mohr distributed among them, but from genuine zeal in the cause of sturgeon-culture.

Much experience has been gained from the experiments of this year. In the first place it became evident that the hatching apparatus would have to be constructed in such a manner that it could be used when the water is rough, and will also serve in places where the currents are sluggish. The changes suggested thereby will be made during the coming winter.

In the second place the removal of the milt from a mature male by cutting and its utilization for the impregnation of the eggs was successfully accomplished. The embryos developed as well as if the eggs had been fertilized with milt emitted in a natural manner, only it took a little longer to hatch them.

A successful attempt was also made to convey freshly impregnated sturgeon eggs in a tin can containing water from the river Elbe, a distance of about one hour across the country, and to transfer them again to hatching-apparatus. These eggs were subsequently hatched in good condition.

It remains to be seen whether the supposition of the board of directors of the Schleswig-Holstein Fishery Association, that more mature spawning sturgeon are caught than is generally known, is correct. If such is the case, it is simply necessary

to further instruct the fishermen, and show them that it will be for their own benefit to become interested in sturgeon-culture. On the Eider, where many sturgeon are caught, no results have been accomplished during the present year. It can not be supposed for a moment that mature spawning sturgeon have not been caught in the Eider as well as in the Elbe; but the fishermen lack zeal and knowledge, and only the persistent labor of many years can succeed in obtaining results on that river.

There are, even at the present time, many men, and among them fishermen, who ridicule the officers of the association when they stand in the water of the Eider in rain and snow to obtain salmon eggs. And still our fishermen see the great results of salmon-culture, which enables some of them to get an annual income of 400 to 500 marks [$95.20 to $119] from comparatively small fishing waters. If the German Fishery Association is willing to continue to aid us, it will find eager workers, especially in the cause of sturgeon-culture in our association.

In the name of the board of directors of the Central Fishery Association of Schleswig-Holstein,

VON STEMANN.

[Letter relative to sturgeon-culture addressed to P. Feddersen, Schleswig, by B. Elsner of the Central Fishery Association of Schleswig-Holstein, March 2, 1887.]

In reply to your letter, which arrived here last week while I was absent on a journey, I have to state the following:

The propagation of sturgeon is a very difficult problem, and many experiments will have to be made before we are able to hatch them in large numbers and with certainty of success.

I transmit, herewith, the annual report of our association, in which I have given an account of the subject.

The most perplexing matter is to obtain a mature spawner and milter at one and the same time. It is particularly difficult to secure mature spawners, and when one is captured most of the roe is generally emitted either while it is being lifted into the boat or during its conveyance to the hatching station. If the spawner is not fully mature and is expected to reach maturity while kept in confinement, the problem becomes still more uncertain.

If a mature spawner and milter are obtained at the same time, the eggs should be fertilized at once by holding the former up by the head so that the tail does not touch the ground. The roe is then squeezed out into earthenware vessels, but not too much in each one. As soon as a vessel contains a sufficient quantity of eggs, some milt is added, and the whole is gently stirred once with the hand, so as to distribute the milt among the eggs. After this, enough water is poured slowly into the vessel to cover the eggs, whereupon a person takes a stout feather and gently stirs them for about ten to fifteen minutes, so that they may not adhere together. The eggs are then transferred to hatching apparatus, which, if possible, is placed in the same water from which the sturgeon were taken. If the temperature of the water is 17° Réaumur, the embryos will hatch in about ninety-two hours.

I am now having new hatching apparatus made, in accordance with the experience gained during our last experiments.

5.—REPORT UPON THE PEARL FISHERY OF THE GULF OF CALIFORNIA.

BY CHARLES H. TOWNSEND.

(Plates XXVIII to XXX.)

The Pearl-Shell Company of Lower California, with an invested capital of $100,000, has been in existence for fifteen years, and is by far the largest corporation engaged in the pearl and pearl-shell fishing in those waters and has more comprehensive privileges from the Government of Mexico.

The territory over which the operations of this company extend embraces the coast of Lower California from Cape St. Lucas to the mouth of the Rio Colorado at the head of the Gulf of California, and the coast of Mexico from Acapulco to the confines of Guatemala.

The franchise by which the company has exclusive privileges over this territory includes all out-lying islands, with exception of the islands of Ceralbo, Esperitu, Santo and San Josef in the Gulf of California, which are controlled by another (the Gonzales) company concerning whose business I am unfortunately not posted.

From four hundred to five hundred men are annually employed by the Pearl-Shell Company. This number, however, includes the crews of vessels as well as divers.

The season for pearl-fishing commences about the first part of May in the vicinity of Cape St. Lucas, whence operations are gradually carried into the Gulf of California, which is usually entered by May 15. During the summer the entire eastern coast of the peninsula is worked, and in October the base of operations is removed from La Paz, the headquarters of the company, to Acapulco, where the fishery is continued for two or three months longer.*

Whatever of romance has hitherto enshrouded the naked diver for pearls in the sea, he is now practically a submarine laborer who uses all the modern diving paraphernalia available.

No longer plunging for sixty seconds into the sunlit green water that covers a coral bank, he puts on a rubber suit with glass-fronted helmet, and suitably weighted with lead, descends for hours to gather pearl-oysters, which are hoisted in a wire basket by his companions in the boat above, who also supply him through a rubber tube with the air he breathes.

In conducting the pearl fishery the divers are located in camps at favorable places

* The west coast of the peninsula as far north as Margarita Island is also included in the lease of this company.

along the shores (see plate XXVIII). Each camp is supplied with a diving suit and an air machine, which is mounted in a heavy barge-like boat, as shown in the illustration (plate XXIX). This boat is daily rowed from camp to each place of operation. Arrived there, one man is diver, one tends his signal rope, one hoists and empties his basket of shells, two turn the cranks of the air-pump, and two are at the oars to keep the boat well over him and carefully follow his wandering course upon the bottom in search of shells. Thus it requires several persons to operate each diving outfit, young boys being frequently employed as attendants.

The diving suits, of which the Pearl-Shell Company keep about seventy on hand, are mostly imported from London. About thirty of them are kept in constant use during the season. They cost about $35 each.

A fleet of five schooners, ranging from 20 to 150 tons, is employed in distributing the diving squads over the area being worked, supplying them with provisions and transporting their ever-accumulating heaps of shells to La Paz. A small steamer, 62 feet long, has recently been added to the fleet.

Two or three large warehouses at La Paz, containing the supplies and stores used in the pearl fishery, I observed, were well stocked with diving machinery, ship stores, and provisions. In fact, there was about the establishment every appearance of a well-regulated and remunerative business.

All equipments, provisions, etc., except the English diving suits, are bought regularly in San Francisco, Cal.

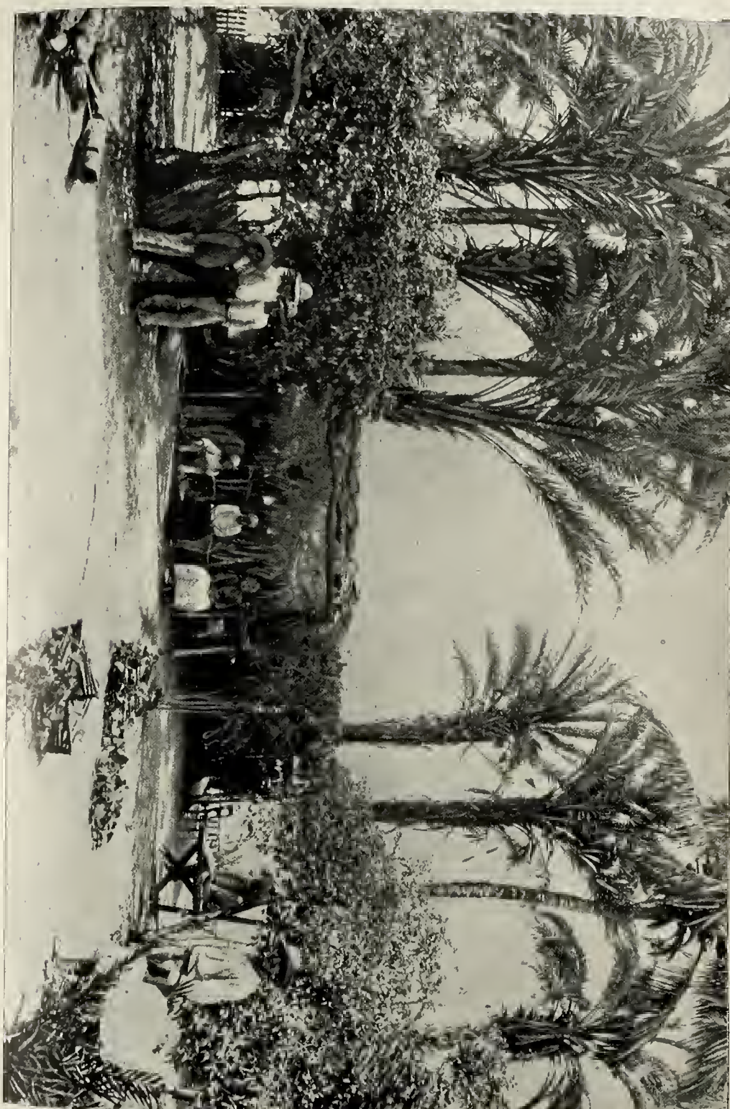
In one of these warehouses at the time of my visit, were stored in sacks 80 tons of shells of the pearl-oyster (*Meleagrina margaritifera*). The principal revenue of the pearl fishery is derived from the shells, the bulk of which are shipped to Europe for manufacture into ornaments, knife-handles, buttons, and all those articles for which mother of pearl is employed. Although the fact is well known to most persons, it may not be out of place to state in this connection that pearl, or mother-of-pearl, as it is usually called, is but the nacreous interior of the shell of the pearl oyster, laid down in successive layers by the mantle of the animal, and that "pearls" are purely accidental growths, "being caused by the deposition of nacre around some foreign object. This nucleus may be a bit of sand, a parasite, or some similar object, but it is said that usually it is an egg which has failed to develop properly." This explanation might be further supplemented by the statement that the so-called pearl-*oyster* is not in any way like the edible oyster of commerce.

Señor Hidalgo, manager of the La Paz pearl fishery, kindly opened his safe and exhibited the pearls representing the gatherings of the three preceding months, about $12,000 or $15,000 worth.

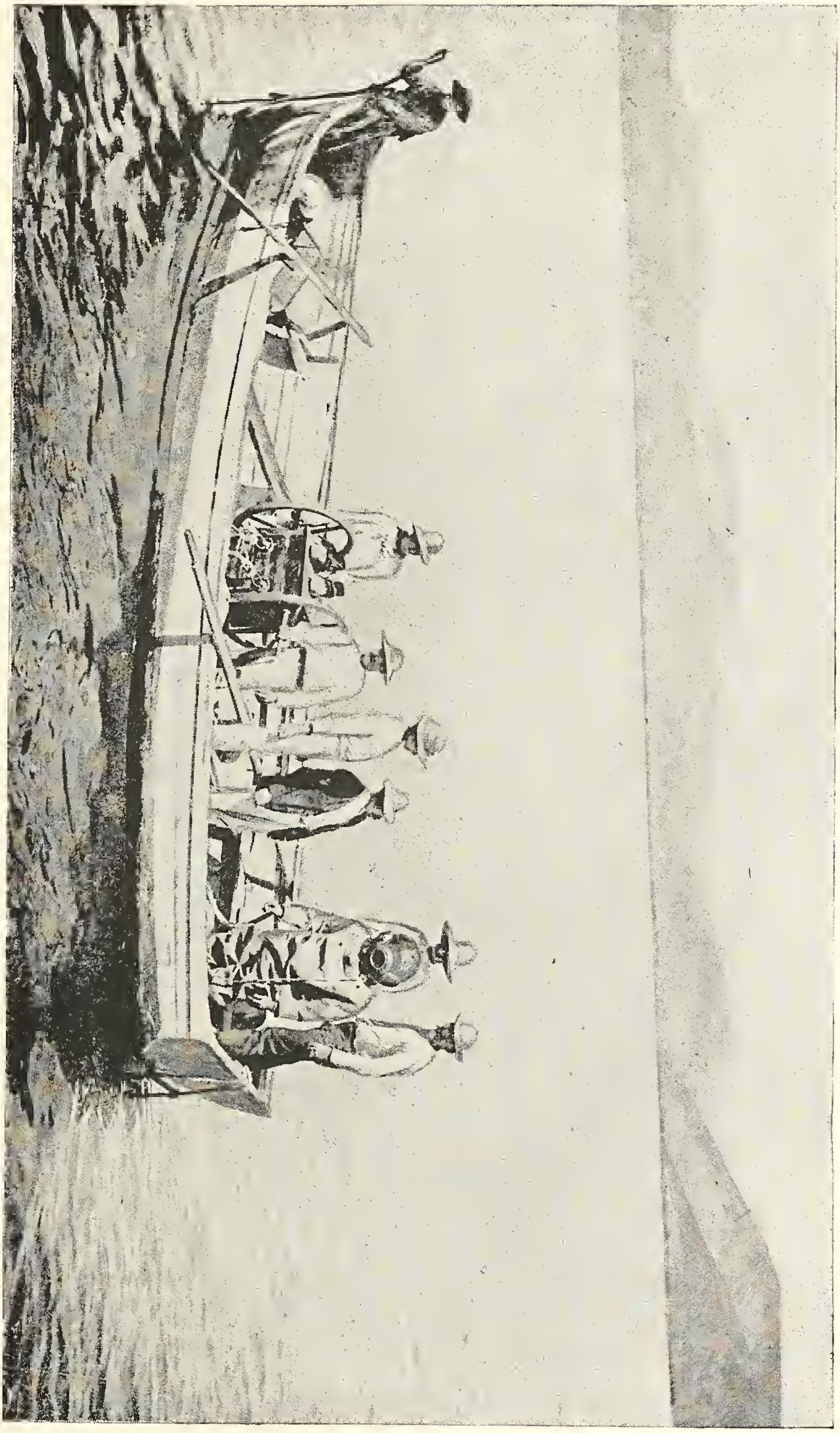
They were separated into eight or nine grades, the lower grades constituting by far the greater number of those exhibited. Most of them were small and imperfect, and of little value. The large, symmetrical, and consequently valuable pearls of the lot, worth perhaps from $500 to $1,000 each, were only a dozen or so in number. One or two of these were black, or of metallic black hues, but I was informed that they were not less valuable than white ones of similar proportions, although not so readily marketable in America as in Europe.

The largest of these pearls, as I remember them, did not exceed, perhaps, in size, the egg of the common blue bird (*Sialia*). It may be remarked that the largest pearl known is 2 inches in length, and weighs 3 ounces.

PLATE XXVIII.



CAMP OF PEARL DIVER. (See page 92.)



APPARATUS OF THE MODERN PEARL DIVER. (See page 92.)

PLATE XXX.

LA PAZ; SHOWING PEARL WAREHOUSES. (See page 92.)

Writing in 1857, Mr. Carpenter stated that "The Gulf of California used to be celebrated for its pearl fishery, but it appears to have been exhausted, and very few shells have been brought of late years." * It is not unlikely that the adoption of the submarine engineer's suit by the pearl fishers of La Paz must have been the step which led to the continuance of the pearl-fishing industry, for the search for shells can now be pursued into deeper waters than in the days of the naked divers, the best of whom could not descend a dozen fathoms. Half that is rather more than a practical working depth.

It must have been difficult to teach these people the use of the diving suit, for during the first year or so after its introduction, a man was lost from the La Paz force almost every month. This Señor Hidalgo ascribed to the giving-way, in nearly all cases, of the rubber air tubing, and said that no accidents had occurred since the introduction of a better grade of tubing. English tubing has been discarded in favor of that manufactured in New York.

An accessory to the diving suit as used at La Paz is a small sheet-iron reservoir of compressed air, which can instantly be made to supply the diver with five minutes' breathing material in case of accident to the air machine or the connecting rubber tube. It goes down with the diver, and its air connection with the diver's helmet he effects by the simple turning of a cock.

In company with Messrs. Gilbert and Alexander, of the U. S. Fish Commission, I went out with a party of divers and made a descent in about three fathoms of water. The sensations accompanying this experience were by no means comfortable, at least not in the excitement, and perhaps nervousness of a first trial, but I can readily understand how a diver accustomed to breathing under such conditions could very thoroughly search the bottom for shells. The light is gray and dim, notwithstanding the intense sunlight above the surface, but within a radius of a few yards everything is distinctly seen. Owing to the pressure of water and the weights necessary to overcome it, a novice has the same difficulty in maintaining the perpendicular as a child that stands alone for the first time.

The pearl fisheries of Lower California, from Magdalena Bay northward, recently in the hands of S. Z. Salario, a citizen of Ensenada, who obtained a six years' concession of the fish, seal, whale, shell-fish, turtle, and pearl fisheries, are now being devoloped by the On Yick Company of San Francisco, a Chinese company, which has purchased a large interest in them. It is understood that Chinese capital and men will be employed principally, except in the branch of pearl fishing, for which Mexican divers have been secured, and that the necessary diving apparatus, boats, etc., have been sent to Magdalena Bay.

A large schooner, the *John Hancock*, is engaged as a tender to this fishery. The *Hancock*, an old vessel, was originally a steamer, and was used as a tender to Commodore Perry's flag-ship when he made the treaty with Japan. For several years past she has been employed in the fishing trade by Lynde & Hough, of San Francisco.

During the cruise of the *Albatross* in the Gulf of California shells of the pearl oyster were frequently brought up by the dredge, from rocky and shelly bottom, in depths varying from 10 to 30 fathoms. In slightly greater depths the number of hauls made were, perhaps, not sufficient to test their existence, but none were obtained.

"In the lower part of the Bay of Mulege, in the Gulf of California, near Los Coyotes,

* Brit. Mus. Catalogue, Mazatlan shells, p. 149.

pearls have been found of rare value and astonishing brilliancy. It was in this bay that Jeremiah Evans, an Englishman, towards the close of the last century, obtained those magnificent pearls of which the collar was made for the Queen of Spain, and which evoked so much admiration at St. Cloud and Windsor Castle. In the time of the Jesuit missionaries the pearl fishery was actively carried on, and produced great wealth to the people of Lower California." *

The following mention of "lucky finds" of pearl fishers is made in a letter to the Philadelphia Record from a correspondent in Lower California:

"They tell us that the best year of modern times at the fisheries was that of 1881, though why the gems should be more plentiful at one time than another none can tell. During that year many were obtained of extraordinary size and great value. Among them was a black one weighing 28 carats, which sold in Paris for $10,000. In 1882 an extremely lucky diver named Napoleano Savin found two treasures, weighing respectively 31 and 45 carats, which together brought $11,000. During 1883 several notable specimens were found. Among them was a light-brown pearl, flecked with darker shades, which weighed 65 carats and sold for $8,600. Another found by Savin was pear-shaped, white, shot with dark specks, which weighed 54 carats and sold for $7,500. These were all sent to Europe and marketed there by Messrs. Gonzalez & Ruffo. In the same year one Publo Hedalgo, a small merchant of La Paz, bought of an unknown Indian, for $10, an oval-shaped pearl, for which he received in Paris the sum of $5,500. It was a light sandy color, of surprising luster, and weighed 32 carats. White pearls, the kind we are most accustomed to survey, are not considered of as much value here or in France as the brown, gray, or speckled ones. Black pearls are still more valuable, and pink ones the most valuable of all."

*Simmonds: Commercial Products of the Sea, p. 420.

6.—REPORT UPON CERTAIN INVESTIGATIONS RELATING TO THE PLANTING OF OYSTERS IN SOUTHERN CALIFORNIA.

BY CHARLES H. GILBERT.

[Plates XXXI to XXXIV.]

ALAMITOS BAY AND NEWPORT BAY, CALIFORNIA.

The coast of southern California contains few harbors or mouths of rivers suitable for the cultivation of oysters. The proximity of the Coast Range of mountains and the limited rain-fall conspire to produce small rivers, which are dry during the greater part of the year, and at other times commonly reach the sea by filtering through the sands thrown up across their mouths by the waves.

Two of the most promising estuaries, Alamitos Bay and Newport Bay, were visited in January, 1889, by the writer, accompanied by Mr. N. B. Miller, of the Fish Commission steamer *Albatross*.

Alamitos Bay lies 3 miles east of Long Beach, a sea-side resort about 20 miles distant from Los Angeles, with which it is directly connected by rail (see plate XXXI). The bay consists of a channel, several miles in length, and with an extreme width of 400 yards, winding through the flat country which here faces the coast. Near the entrance to the bay it receives from the east the New San Gabriel River, and higher up a number of narrow channels, Croaker Strait and Mud Creek from the east, and Headquarters Creek, with three smaller channels, from the west.

At a distance of 2½ miles from the entrance to the bay, and above the mouth of Mud Creek, the channel is about 150 feet wide and 6 feet deep at low water. At this point there is exposed, at low water, a flat of perhaps 150 acres, consisting of soft sand covered with a thin layer of mud, and said to be constantly covered at high tide. In the channel the temperature was 60° Fahr., and the specific gravity 1.022187. No native oysters are found thus far up the bay, but cockles and scallops abound. The bottom consists of sand covered with a thin layer of blue mud.

Down the channel toward the mouth of Mud Creek the width increases somewhat, and the depth varies from 5 to 10 feet for a short distance above the creek; the bottom is strewn with scattering oysters. Mud Creek has an average depth of 2 feet for about 2 miles. It contains more mud than other branches and fewer oysters, those found being mainly toward its head. No fresh water is known to flow from it into the main channels, the specific gravity at its mouth being 1.023187.

Between the mouth of Mud Creek and Headquarters Creek the depth in the channel varies from 7 to 9 feet, with a bottom of mixed sand and mud. Headquarters Creek contains an abundance of native oysters, cockles, and scallops, and the water

at its mouth shows a specific gravity of 1.021587. Two creeks entering the channel lower down also contain oysters, which are said to cover the bottom of one of them for a distance of a quarter of a mile. Along this part of the main channel, the depth varies from 10 to 19 feet, and the bottom consists of sand covered with mud.

A short distance above the mouth of the New San Gabriel River, the channel widens rapidly and becomes shallower, the depth varying from 6 to 8 feet, with a bottom of mud and sand and broken shells. Just above the mouth of the river, the specific gravity was 1.015890, and opposite the mouth 1.011948. It is evident that at high tide much fresh water must be backed up into the main channels, and our specific gravities, taken at low water, show a minimum amount of fresh water for that time of year.

The river is said to average 6 feet in depth for a distance of 5 or 6 miles, the tide backing up for the entire distance. The bottom is reported to be sand, with some mud. During the dry season the river ceases to flow in its lower course, but the bay is said to derive a constant supply of fresh water from the numerous springs flowing into it. At the time of our visit about 5 feet of water was found on the bar.

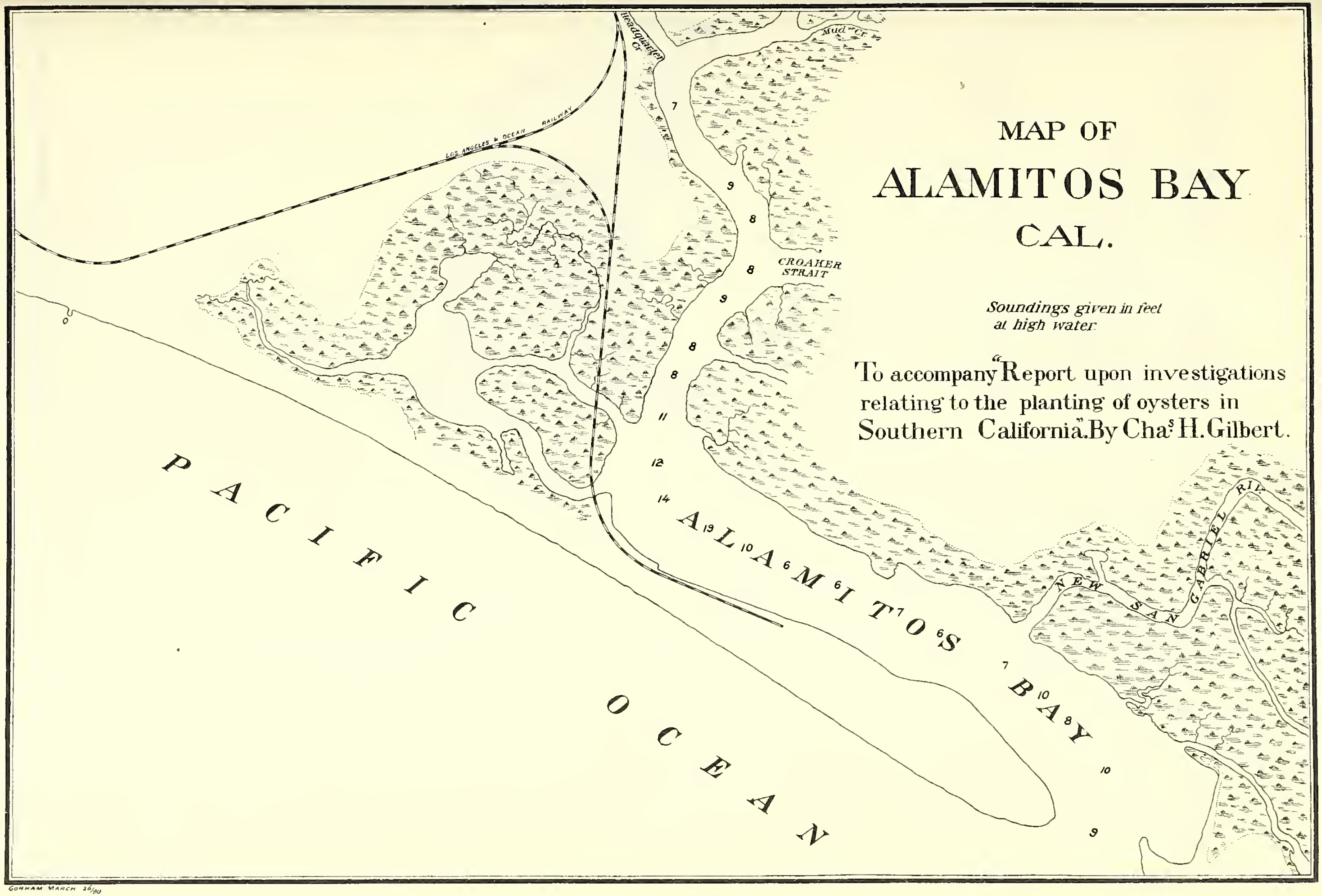
Newport Bay, distant about 10 miles from Santa Ana, is the estuary into which flows the Santa Ana River (see plate XXXII). It is a much larger body of water than Alamitos Bay. In its lower portion it is about one-half mile wide, but it narrows at its entrance and in its upper part. Near the mouth of the river, there is sufficient water on the bar at high tide to admit the passage of small steamers, but the bar is constantly shifting and is unreliable. The bottom of the bay consists of clean hard sand, with little or no admixture of mud. Near the mouth of the river, flats are exposed fully 2 miles wide, the sand of which they are composed being covered with a thin layer of mud.

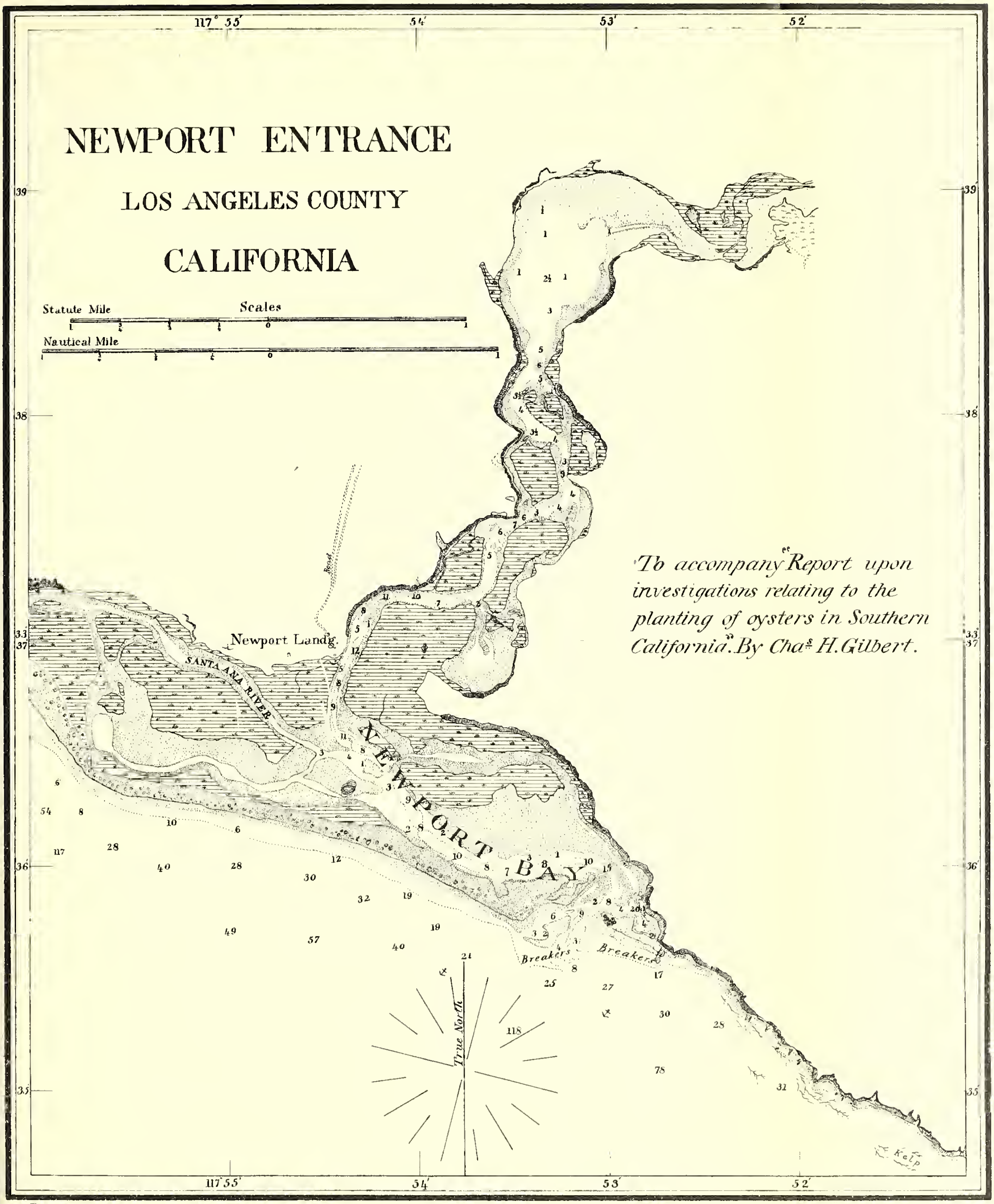
From the head of the bay, a channel known as San Joaquin Bay extends eastward for 2 or 3 miles, winding among the hills. The bottom of this channel is of mud, very soft in spots, but with many banks of native oysters, which reach a large size. Near the head of San Joaquin Bay, fresh water is said to enter from springs having a constant flow throughout the year; but the amount obtained from this source is apparently small.

Aside from springs, the fresh-water supply of Newport Bay is precarious, being wholly derived from the Santa Ana River. During the dry season, the water of this stream is drawn off for irrigation purposes and it becomes dry in its lower course for at least seven months in the year. At the time of our visit, in the midst of the rainy season, the temperature of the water was 60° Fahr., and the specific gravity at medium high water off the mouth of the river 1.024000. At two points farther down the bay the temperature was the same, and the specific gravity 1.023000 and 1.024000. Later, off the mouth of the river, at low water, the specific gravity was 1.01540.

On the wide sand-bar lying between the western shore of the bay and the ocean beach, a well dug into the sand to a depth of 9 or 10 feet furnishes fresh water for a sportsman's hotel located at that point. Salt water is, of course, struck at a depth of a few feet more. On this bar a pond of salt water produces native oysters of large size, said to be of good flavor.

Between Alamitos and Newport Bays, lie Anaheim Bay and the mouth of Los Bolsos Creek. The former is said to have a considerable amount of fresh water rising into it the year round, but has no stream entering it. The mouth of Los Bolsos Creek is an estuary as large as Alamitos Bay, and probably has a more constant supply of


MAP OF
ALAMITOS BAY
CAL.
Soundings given in feet
at high water
To accompany "Report upon investigations
relating to the planting of oysters in
Southern California". By Chas. H. Gilbert.
Headquarter Cr.
Mud Cr.
CROAKER STRAIT
LOS ANGELES & OCEAN RAILWAY
ALAMITOS BAY
NEW SAN GABRIEL RIV.
PACIFIC OCEAN
GORHAM MARCH 26/90



Rogers. April 90.

Copied from U. S. Coast Survey Chart.

fresh water. The bottom is said to be sand overlaid with mud, and to be covered with native oysters.

With the possible exception of False Bay, near San Diego, which has not been reported on, the four bays above mentioned are probably the only ones in which the experiment of oyster-culture could be tried in southern California with any prospect of success. Of these, Alamitos and Newport Bays are the most easily accessible, and the conditions at Alamitos Bay seem on the whole the most favorable. Before making any practical experiments in this direction, it would seem advisable to obtain reports from these bays during the dry season, in order to test the amount of fresh water entering them at that time.

THE OYSTER BEDS OF THE GULF OF CALIFORNIA.

The edible oysters of the Gulf of California are found only along the eastern shore of the Gulf, south of Guaymas (see plate XXXIII). Here, in lagoons near the mouth of the Yaqui River, farther south in the vicinity of Agiabampo and Altata, and probably at other points, extensive natural beds are found.

Two lagoons north of the mouth of the Yaqui River were explored by the writer March 31 and April 1, 1889, during the investigations of the steamer *Albatross* in the Gulf of California. Owing to the inaccuracies and incompleteness of the charts of this part of the coast, I was unable to ascertain whether or not the two lagoons were connected with each other, or even to make sure of their proper designation. They are referred to in this report as the Upper and the Lower Algodones Lagoons. The Upper Algodones, the northernmost of the two, is a broad sheet of water separated from the Gulf by a sand-spit, through which are one or more narrow tide-ways. The water is everywhere shallow, and the bottom is composed of such a mixture of fine sand and mud as prevents extensive shifting by currents.

The oyster beds are mostly in the form of hummocks with circular or oval outlines, each having usually in the center a heap of dead shells raised two or three feet above high-water mark (see plate XXXIV). The living oysters are almost wholly confined to the areas exposed at low water, the channels between the hummocks being bare, even when but 2 or 3 feet deep. The oysters are firmly grown together in masses of considerable size, the lowermost ones being usually dead and partly buried in sediment. Deeper within the banks other shells were found buried in the sand and mud, some of these having probably been smothered by the superimposed oysters and still retaining their vertical position and cohering in masses.

The heaps of dead shells in the center of the beds I was unable to account for, unless indeed, as was suggested to me, they were merely heaps of refuse shells left by the Indians, who formerly found here an important source of food. This theory was sustained by the fact that the shells of the heap were all single valves, and of large size.

A few other beds observed seemed newer than those described, and covered uniformly flats exposed at low water. These beds were sometimes of larger extent, were without definite shape, and did not contain the central heap of dead shells. Other exposed flats, lying side by side with the oyster-beds and apparently offering precisely the same conditions, were wholly bare.

The Lower Algodones Lagoon, the opening to which lies but a few miles north of the Yaqui River, consists of numerous winding channels, running a long distance

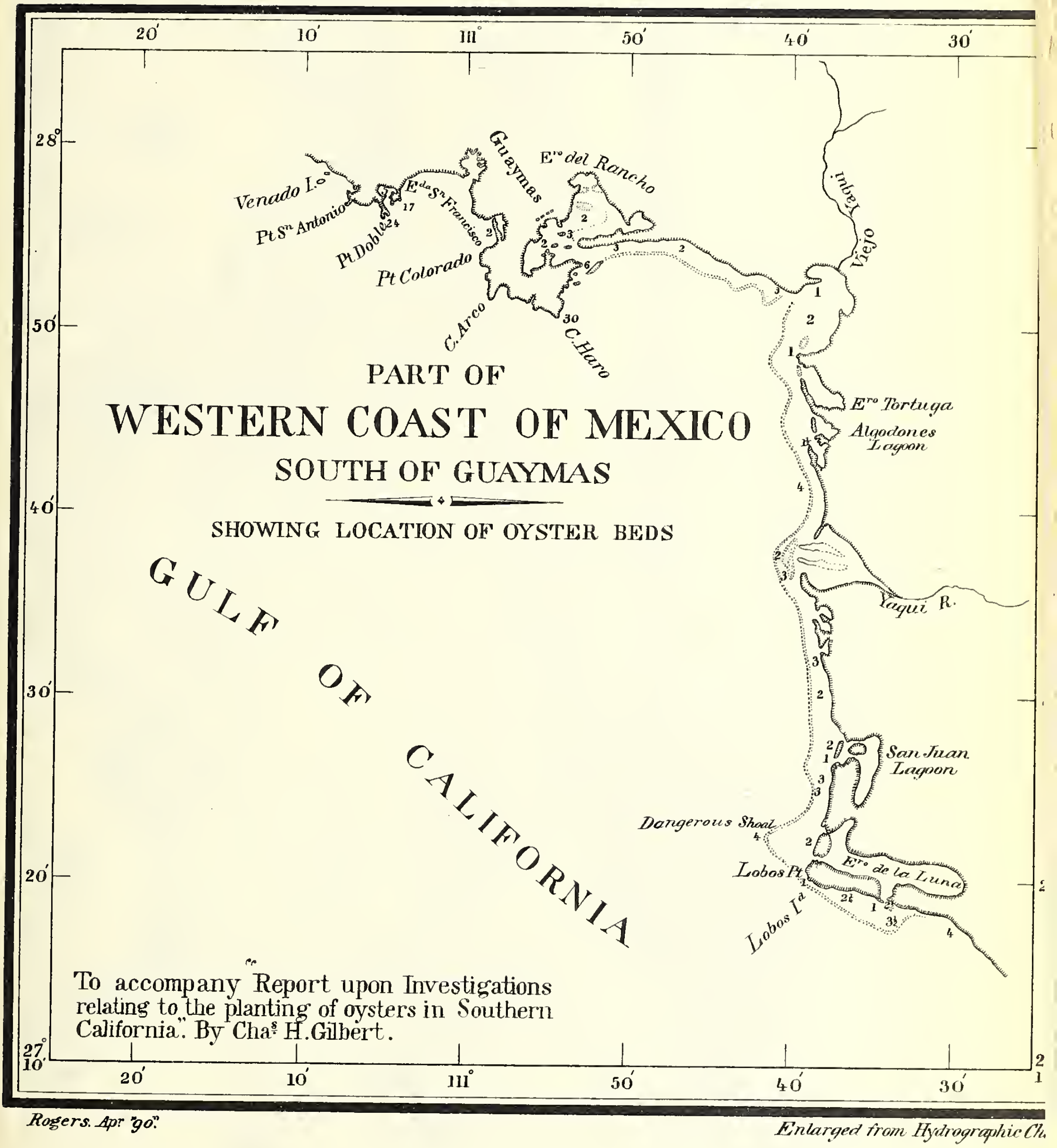
into the level low lands which here front the coast. The oysters were here found under the same conditions as those in the upper lagoon, growing along the shores, or forming hummocky islands dotting the shallower portions of the lagoon.

I was unable to learn that any fresh water flowed directly into either of the lagoons; there was, however, much difference in the amount of fresh water which they contained, the upper lagoon having almost the same density as sea water, its specific gravity being 1.026508. The lower lagoon contained much more fresh water, the specific gravity being 1.022808. Whether this was owing to the state of the tide, different in the two cases, or to the proximity of the river to the lower lagoon, I was unable to decide.

The Yaqui River is a deep swift stream, reaching the Gulf through a single well-defined channel, which widens but little towards its mouth. Even during the dry season it discharges a large volume of water into the Gulf, the specific gravity at our anchorage, 3 miles distant from the shore (1.006808), showing the water to be only slightly brackish. This volume of fresh water may spread far enough along the coast to be backed by the tide into the lower lagoon. No oysters were found in the river, which was explored for a distance of about 4 miles.

The Gulf oysters we found to be large, fat, and of excellent flavor, being uniformly pronounced by our ship's company to be equal to the best Eastern product. They are now used only to supply the very limited demand at Guaymas. The Indians gather them by the boat-load, selecting only the larger ones, carry them to Guaymas, and preserve them until wanted by depositing them in the bay. We were informed that the oysters deteriorated after being kept in the bay four or five weeks, but this was denied by others.

As to the propriety of attempting to transplant the oysters to the coast of California, I am in some doubt. The fact that almost the entire littoral fauna of the Gulf differs from that found to the northward seems to indicate the existence of dissimilar conditions which would militate against success. The temperature in the lagoons along the Gulf during the winter and early spring is about 70° Fahr., as compared with 60° in the bays of southern California. And during the rainy season in the Gulf, the amount of fresh water found in those shallow lagoons must be much greater than was found by us in the dry season, and probably more than could be looked for at any time in southern California.


PART OF
WESTERN COAST OF MEXICO
SOUTH OF GUAYMAS
SHOWING LOCATION OF OYSTER BEDS
GULF OF CALIFORNIA
Venado I.
Pt Sn Antonio
Pt Doble
Eda Sn Francisco
Pt Colorado
Guaymas
Ero del Rancho
C. Arco
C. Haro
Yaqui Viejo
Ero Tortuga
Algodones Lagoon
Yaqui R.
San Juan Lagoon
Dangerous Shoal
Lobos Pt
Ero de la Luna
Lobos Id
To accompany "Report upon Investigations relating to the planting of oysters in Southern California". By Chas H. Gilbert.
Rogers. Apr. '90.
Enlarged from Hydrographic Ch.

DEAD OYSTER SHELLS IN THE CENTER OF OYSTER BED. (See page 97.)

7.—ON CERTAIN WART-LIKE EXCRESCENCES, OCCURRING ON THE SHORT MINNOW, CYPRINODON VARIEGATUS, DUE TO PSOROSPERMS.

BY EDWIN LINTON.

[Plate XXXV.]

On August 20, 1889, while at the U. S. Fish Commission laboratory, Wood's Holl, Mass., I obtained a specimen of the short minnow (*Cyprinodon variegatus*), having upon its body several fungoid, wart-like excrescences, which, upon examination, proved to be occasioned by the presence of psorosperms. These parasitic protozoans are regarded as related to the Gregarinidæ on account of their resemblance to the pseudo-navicellæ of that family, but their exact nature is not yet well understood. They have been recorded by naturalists from a number of European fishes, among which are several species of perch (*Cyprinus rutilus*, *C. erythropthalmus*, and *C. leuciscus*), other perch-like fishes (*Lucioperca*), the white-fish (*Coregonus fera*), and some of the fresh-water minnows (*Cyprinodon*). They have also, doubtless, been observed hitherto on kindred American fishes, but so far I have been unable to find any literature describing their occurrence in America.

The specimen of *Cyprinodon variegatus*, which I had the opportunity of examining at Wood's Holl, had three of these fungoid masses on the left side of the body and one on the right. The latter is shown in the sketch, Fig. 1.

One of those on the left is also shown in part in the same sketch, where it projects above the line of the back. This mass was about 6 millimeters in diameter; it was situated a short distance behind the eye and above the operculum; another behind the gill-slit and extending diagonally backward and downward was 10 millimeters long and 4 millimeters broad; another behind the latter and near it was 4 millimeters long and 2½ millimeters broad. These masses are irregular in outline and elevation; they protrude as much as 3 millimeters above the general surface of the body; they do not appear to consist of closed cysts.

The abnormal growth is apparently confined to the superficial muscular and subcutaneous tissue. Sections carried through one of the masses reveal clusters of psorosperms lying in the interstices of the connective tissue, and patches of dark pigment, with a few capillary vessels. The skin of the host overlying these tumors is more or less cracked and broken, and the scales scattering.

When a piece of one of these abnormal growths was placed on a slide in water and gentle pressure applied myriads of oval bodies, such as are shown in Figs. 2–4, were set free. These spore-like bodies when liberated lay motionless at the bottom of the water. During all my observations on them no movements were discovered.

They are of very uniform size and shape. In their usual position they appear to be flattened or disc-shaped; when turned on one edge they are seen to be lenticular. The outline is always elliptical, the longer diameter being about 0.0139 millimeter, the shorter, 0.0110 millimeter. Their thickness was not so certainly made out, but in one individual, which appeared to be standing on one edge, it was about 0.008 millimeter. Fig. 5 is a sketch of an ideal section along the shorter diameter.

Near one end of each there are two transparent, pyriform, refractile bodies, their smaller ends converging and directed toward the nearest border. These are the twinned vescicles of Balbiani and the polar capsules of Bütschli. In many cases smaller supplemental refractile bodies were seen at the base of the pyriform bodies. This phenomenon is shown in Fig. 2. These have the position but not the appearance of Bütschli's dark granules. The remainder of the interior is filled with a clear viscid fluid, which in some cases has a few small refractile particles in it. The walls are rather thick and quite firm, with a sharp, clear, entire outline. In optical section there is often the appearance of a third refractile body behind the pyriform vescicles. This is due, in the fresh specimens, to the thick transparent walls and the viscid refractile fluid interior. When treated with certain reagents this viscid fluid seems to separate from the wall so as to appear as a nuclear body. This appearance is shown in Fig. 7, which represents one of the psorosperms after having been treated with acetic acid. The two filiform appendages, said to be characteristic of these animals, were not seen satisfactorily in fresh specimens. Some specimens were placed in one-half per cent. osmic acid for a few minutes and afterward examined with a high magnifying power, but no appendages were distinguishable. It is likely that a longer continuance in osmic acid would be followed by better results, as the material in the walls is but slowly attacked by even concentrated sulphuric acid.

Other examples after being fixed to a slide by means of alcohol were stained with methyl green, and subsequently with eosin. The pyriform vescicles were not stained deeply, while the walls were deeply stained and differentiated from the plastic, homogeneous material which fills the interior.

In some of the individuals that had been subjected to the action of osmic acid and were viewed under especially favorable conditions a small pore was discerned at the apex of each of the pyriform vescicles. These are evidently the orifices from which the filiform appendages issue. The osmic acid preparations also enabled me to perceive for the first time a feature that was afterwards seen in specimens treated with sulphuric acid and which appears to be constant, viz, a low rounded ridge which extends along the edge of the animal from tip to tip, Fig. 6. This feature is noticed and figured by Bütschli in his account of myxosporidæ from the gills of certain fresh-water cyprinoids.

Specimens were kept in sea water for about ten days and observed from time to time, but no noteworthy changes were observed to take place. Although the connective tissue of the mass underwent maceration, the psorosperms showed but little indication of the effect of maceration. At the end of the eighth day a few were noticed in which the walls seemed to have given way, in which case the pyriform bodies were liberated. The latter were still intact.

Upon treating a small piece of the abnormal tissue with sulphuric acid brisk effervescence ensued. As the psorosperms remained with but little change under this severe treatment, the effervescence was plainly from some other source. Another piece

of the tissue was subjected to the action of strong potassic hydrate. This dissolved out the connective tissue and left a residue which consisted of the psorosperms, still unaffected by the reagent, and small calcareous particles of extremely irregular shape. Some of the latter are shown in Fig. 14, and three of the calcareous particles more highly magnified, along with some of the psorosperms, in Fig. 15. The walls of the psorosperms withstand the action of concentrated sulphuric acid and of a saturated solution of potassic hydrate for a long time. When treated with iodine they stain yellowish brown. When placed in glycerine the walls of the psorosperms collapse.

The action of sulphuric acid was most successful in bringing out certain details of structure which had otherwise escaped detection. One of the first effects of concentrated sulphuric acid which was observed, and which resulted almost immediately after application of the acid, was to cause the protrusion of two filamentary appendages from the anterior end, *i. e.*, the end at which the polar vescicles lie. In some cases these threads are nearly straight, in others they are undulate, and a few were thrown into a more or less close spiral.

The latter gives some hint of the retracted condition of these threads, and confirms Balbiani's view that the twinned vescicles which are found in all the psorospermæ serve normally as sheaths for the threads which, according to that author, always issue from the end of the animal near which the converging ends of the vescicles lie.

Zschokke (9) figures a psorosperm from *Coregonus fera*, which bears a very close resemblance to these from the short minnow. The two filiform appendages, however, appear to be exceptional, in that they issue from the end opposite the polar vescicles. The psorosperms described by Zschokke occur in cysts from the size of a pea to that of a walnut, fixed firmly among the muscles.

These cysts are white, oval, inclosed in a thick envelope without apparent structure and containing a whitish liquid of milky appearance. Examined under the microscope thousands of psorospermæ may be seen disposed among the granular protoplasm. The psorospermæ described by Bütschli from the fresh-water cyprinoids were also inclosed in a cyst, in which were calcareous particles.

In some cases the psorosperms which have been treated with concentrated sulphuric acid have ejected the polar vescicles bodily with the filaments extruded (Figs. 12, 13). The threads are of the same diameter throughout and are not extremely slender. The distal ends are truncate. The organs, therefore, do not resemble flagella. The appearance of one of these vescicles with its thread is strikingly suggestive of the nematocyst of a cœlenterate. The threads stain yellowish-brown with iodine.

One psorosperm was observed which appeared to have three threads, two normal and a third at the opposite end. This appearance was at first thought to be due to one of the free vescicles getting behind the body of a psorosperm. Such a posterior thread has been noticed by other observers and is figured by Bütschli (8).

When treated with acetic acid a nuclear vescicle was clearly defined in the apparently homogeneous tissue behind the polar vescicles. A similar appearance was noticed in a few that had lain in sea water for a period of eight days. None of the reagents employed brought out the diagonal striæ represented by Bütschli in his figures of the polar vescicles of the myxospores from the fresh-water cyprinoids, and which are due to the thread coiled up in a spiral within the vescicle. In other respects Bütschli's figures of cyprinoid myxospores bear a very close resemblance to these psorosperms from *Cyprinodon variegatus.*

In some seasons the short minnows are quite commonly affected with this parasite, as I have observed in previous years, and as I am informed is the case by Mr. Vinal N. Edwards, who has had a long and extended experience in observing our coast fishes. I am indebted to Dr. E. L. Mark for assistance in obtaining some of the literature of this interesting subject, especially Bütschli's excellent paper.

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EXPLANATION OF PLATE XXXV.

1. *Cyprinodon variegatus*, with excrescences caused by Psorosperms, one on right side and another on left side showing above outline of back. x $1\frac{1}{2}$.

2–3. Psorosperms with supplemental refractile bodies behind the polar vescicles. In Fig. 3 there are a few small refractile globular masses near the posterior end.

4. An individual treated with osmic acid, showing pores at the apices of the polar vescicles.

5–6. Specimens lying on the edge, showing the rounded elevated ridge which follows the edge.

7. Specimen treated with acetic acid. A nuclear body is defined back of the polar vescicles.

8. Diagram of transverse section, showing lenticular shape of psorosperms.

9–11. Specimens treated with concentrated sulphuric acid; 9, with a few refractile bodies and one thread exserted; 10, an example with both threads exserted and a number of small refractile globules; 11, a specimen in which the plastic fluid interior is aggregated into a single refractile body; a thread also appears at the end opposite the polar vescicles.

12–13. Polar vescicles with their threads, liberated from the body of the psorosperms after treatment with concentrated sulphuric acid. Nos. 2 to 13 all highly magnified.

14. Calcareous bodies found in the abnormal tissue associated with the psorosperms. x 200.

15. Three of the same, with a few psorosperms. Sketch made from material that had been subjected to the action of potassic hydrate. x 400.

16. Psorosperms in place. (*a*) nests of psorosperms; (*b*) section of a blood capillary; (*c*) connective tissue. Sketch made from a section of decalcified abnormal tissue.

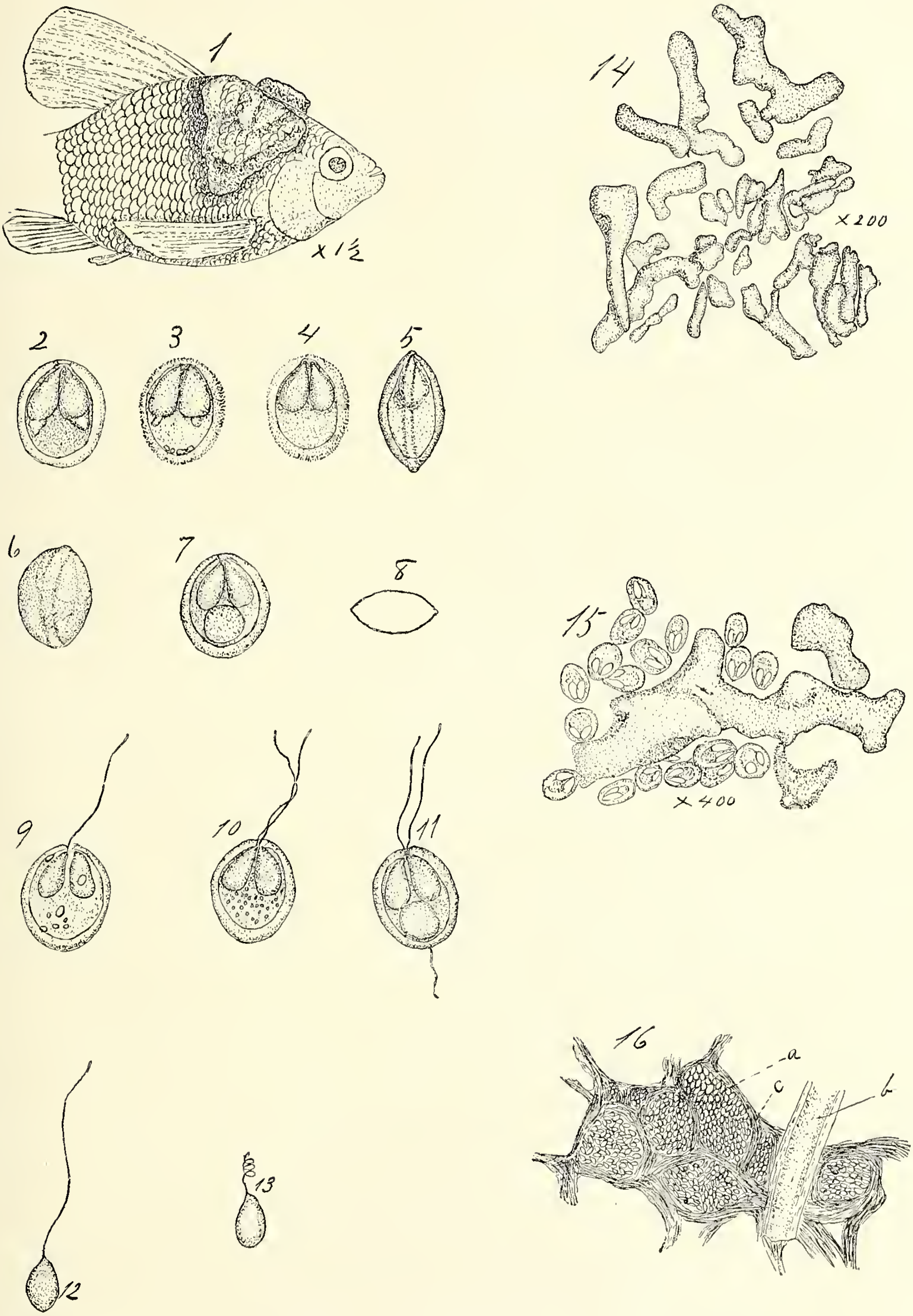
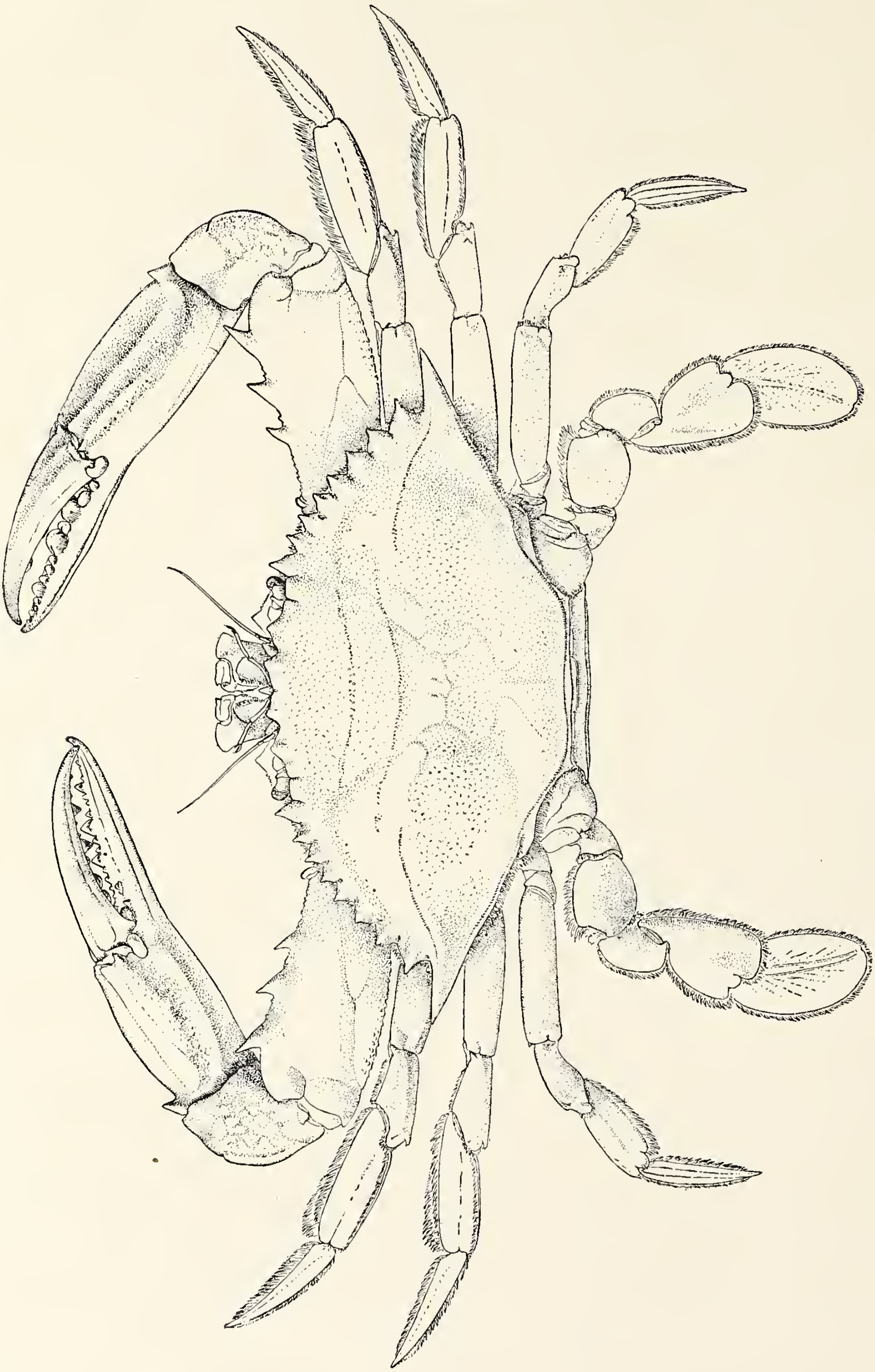

1
x 1½
2
3
4
5
6
7
8
9
10
11
12
13
14
x 200
15
x 400
16
a
b
c

PLATE XXXVI.



BLUE OR EDIBLE CRAB (*Callinectes hastatus*).

(Four-fifths natural size.)

8.—NOTES ON THE CRAB FISHERY OF CRISFIELD, MD.

BY HUGH M. SMITH.

Plates XXXVI to XLI.

SYNOPSIS.

I.—THE SOFT-CRAB FISHERY AND TRADE.

A.—The Fishery.

1. *On the natural history of the crab.*—The species which is the object of the fishery at Crisfield is the blue or edible crab (*Callinectes hastatus* Ordway), (see plate XXXVI) which occurs on the Atlantic coast from Massachusetts to Mexico, and is abundant thoughout Chesapeake Bay, ascending all the tributary streams to the limit of salt water.

Although the abundance of the crab and its extended distribution make it readily accessible to the biologist, and notwithstanding the fact that its commercial importance and morphological characters would seem to bespeak for it the close attention of the student, its life history has been only partially investigated, and scarcely anything has been published regarding its spawning habits and the conditions of its existence during the winter months.

Beyond certain somewhat narrow limits, the crab is very susceptible to extremes of temperature; and not being possessed of the ability or the propensity to make extensive migrations in order to overcome the untoward influences of heat and cold, it is obliged to accomplish the same ends by retiring in winter to the deeper waters near at hand, where, on the bottom or half buried in the mud, it is surmised that it enters into a condition of lowered vitality, returning to the shoaler water with the approach of spring.

Between the months of May and October, inclusive, the water in the vicinity of Crisfield is of a sufficiently high temperature to permit the crabs to leave the deeper retreats frequented at other times, and to remain in the more shallow water, where alone it is possible for the fishery to be prosecuted.

At certain periods, varying in frequency with the rapidity of growth, the crab sheds its shell, becoming a soft-shell or soft crab. Young crabs moult often, but it is thought that adults throw off their coverings only once or twice a year, usually immediately after the spawning season. A crab approaching the shedding process is variously known among the fishermen as a "peeler," "shedder," "buster," "comer," "long-comer," or "short-comer." A "peeler," "shedder," or "buster" is one whose shell has begun to crack, while a "comer," "long-comer" or "short-comer" is preparing to moult, and the shell is loosening, but has not yet split. This distinction is not everywhere observed, as the use of the vernacular names varies with the locality. In the Chesapeake region, "peeler," "shedder," and "buster" are the names most commonly met with, although the others are also heard.

It is a matter of considerable importance in connection with the fishery to be able to determine whether a crab has or has not recently completed the shedding process. Unless the crustacean is taken in hand immediately after moulting, it quickly becomes a hard-shell or hard crab, passing through the stages known as "paper-shell" and "buckler," and as such not possessing the market value of a soft crab, or one that

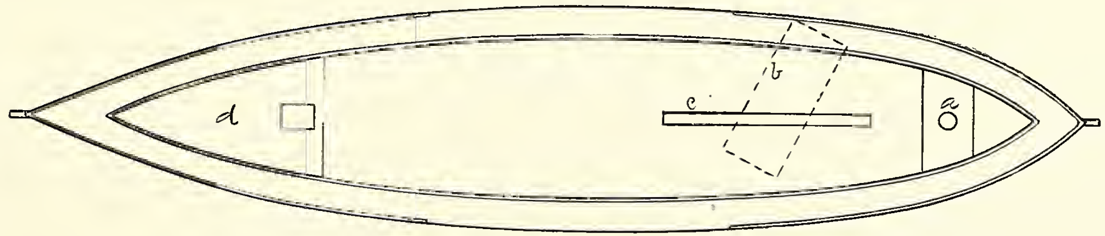


Fig. 1.

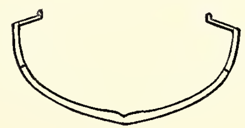


Fig. 2.

PLANS OF DUGOUT CRAB CANOE.

FIG. 1. Deck-plan: *a*, mast-hole in forward thwart; *b*, culling board; *c*, center-board box; *d*, after-platform seat.
FIG. 2. Midship cross section, showing construction.

Drawn by H. M. Smith.

has not undergone moulting. The fishermen and shippers, as a rule, can determine with a facility and accuracy that is puzzling to the uninitiated, if a crab has recently changed its shell, and, if not, about how many days will elapse before such a change occurs.

2. *Origin and development of the industry.*—The practice of taking soft and "peeler" crabs, impounding the latter until after the shedding process and then shipping them to market, is of comparatively recent origin at Crisfield. It began on a very small scale about fifteen years ago. Mr. John Landon and a few others, who inaugurated this enterprise in order to utilize the large supply of crabs in this section, laid themselves open to great ridicule and acquired the ignominious title of "crab-breeders." It was only a short time, however, before the business grew in popular favor, many more people became directly interested, and the fishery progressed uninterruptedly.

3. *Present condition of the fishery.*—Few persons outside of Crisfield are aware of the great proportions to which the crab fishery of that place has attained in recent years. Since 1880, when the yield of the entire State was much less than that of the present output of Crisfield alone, there has been a rapid increase, so that now the capture and handling of soft and "peeler" crabs is the most important occupation of the people during nearly half the year, affording steady, profitable, and inarduous employment to large numbers of persons who would be otherwise unemployed at this time. The limit of growth has not yet been reached, and it is probable that the near future will witness even a more extensive development than was made in 1888, when the increase over the previous year amounted to about 13 per cent. in the number of persons employed, 78 per cent. in the number of crabs taken, and 81 per cent. in the value of the catch to the fishermen.

4. *Fishing grounds.*—The Little Annemessex River, on which Crisfield is situated, is the principal ground now frequented by the fishermen, although the waters bordering on the marshy land on either side of the mouth of this river are also visited.

So long as the supply is maintained the crabs will be taken in the localities nearest the market, and up to the present time the large majority of the crabbers have found but little occasion to go to very distant grounds.

A fair proportion of the crabs which are handled by some of the Crisfield shippers are caught in the waters adjacent to Tangier and Smith's Islands, where the crabs abound, but where there is no demand for them. They are therefore taken to Crisfield, either by the men who catch them, or, as is more frequently the case, in collecting boats sent out by the dealers.

Should the time ever come when crabs become scarce in the immediate vicinity of Crisfield, there will be no lack of suitable grounds at no very great distance. The marshy islands in Chesapeake Bay off Crisfield are available, as are other favorable localities up and down the shore. The Dammeron marshes, on the western side of the bay, immediately opposite Crisfield, should be mentioned in this connection. They are considered the best crabbing grounds in this entire section of the Chesapeake, but are seldom visited, owing to their distance from shipping centers. The few fares that have been taken there of late years have been very large, but there is danger of losing a considerable part of the catch, because of the liability of soft crabs to die when exposed in a boat for the length of time required to sail to Crisfield. It is thought that the introduction of a comparatively inexpensive class of small steam-vessels, as sug-

gested by Captain Collins in his paper on improved types of fishing-vessels,* will greatly advance the crab interests of Crisfield, as it must the other fisheries of the town and region, by making available new and productive fishing grounds, such as the marshes referred to.

5. *Fishing season.*—The season for soft crabs begins early in May and continues until the middle of October, when the oyster fishery becomes paramount. About five months of fishing are thus enjoyed, although the actual length of the season varies each year within certain limits, depending on the weather.

6. *Abundance of crabs.*—The sounds, rivers, creeks, and marshes in the vicinity of Crisfield may be said to teem with crabs. So great is the supply, in fact, that it seems almost inexhaustible. The fishery will probably never result in serious diminution of the species, for as it is now prosecuted only those individuals are taken which have come up into comparatively shallow water, while in the deeper water they are undisturbed.

All the testimony available goes to show that in 1887 and 1888 the supply was fully equal to, if not in excess of, that of any previous year.

7. *The crab boats.*—None of the boats used in the crab fishery are of sufficient size to be documented at the custom-house, the greater number being the small, open sail-boats of the style known throughout the Chesapeake region as canoes, corrupted to "kunners," in the vernacular of the fishermen (see plates XXXVII, XXXVIII). They range from 18 to 25 feet in length, are built of three pieces of timber, are round-bottomed, have wash-boards, and carry one or two sails and usually a jib. Board-built, flat-bottomed bateaux and skiffs are sparingly used, and three or four small sloop-rigged, decked boats are also employed (see plate XXXIX).

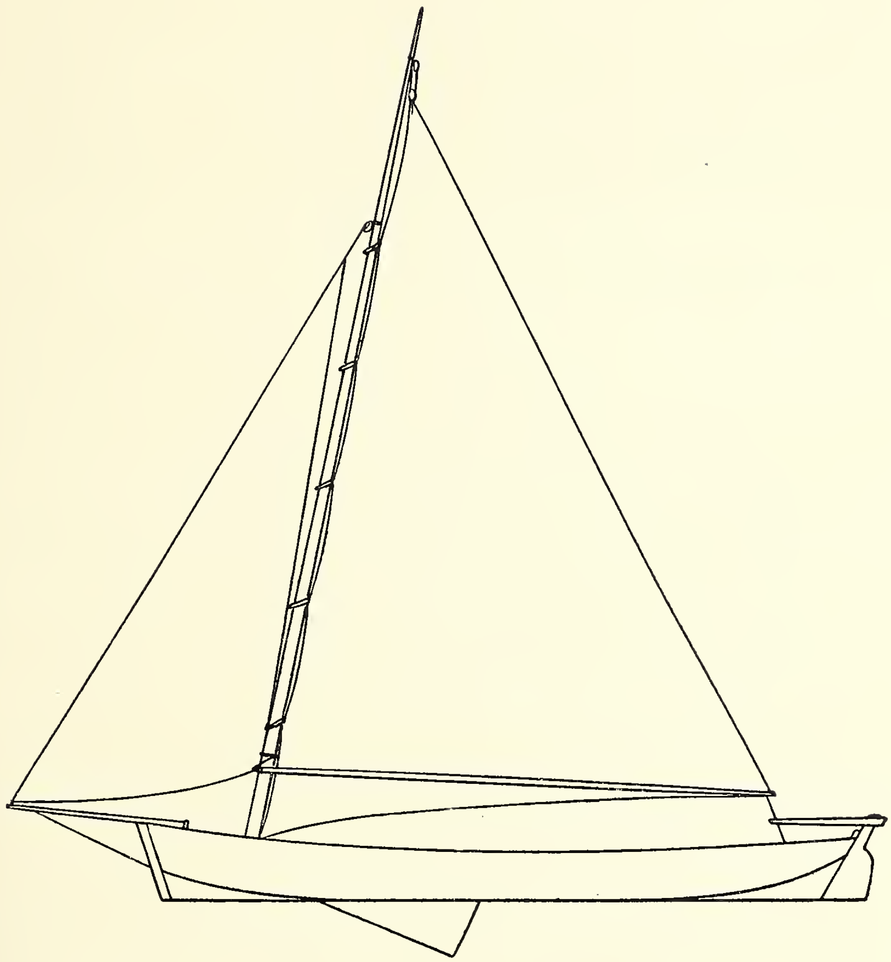
The boats vary in value from $20 to $150, the decked boats and canoes being the most expensive. Forty dollars would represent about the average value.

The crew of each boat consists of from one to three men, a large majority of the boats carrying only one person. After the close of the crab season the same men engage in oystering with the same boats.

8. *Apparatus and methods of capture.*—Two forms of apparatus are in use in the vicinity of Crisfield. One, made of iron bars, known as the dredge or scrape, much resembles the ordinary oyster-dredge in shape, but is lighter, and is provided with a pocket of netting (see plate XL). It weighs about 20 pounds, and costs from $2.50 to $4. Dip-nets are also employed in this fishery, these being most popular with the fishermen of the outlying islands, who do but little dredging; dip-nets are also used at Crisfield, but to a limited extent, and are chiefly fished from the unrigged, flat-bottomed boats.

One or two dredges are carried by each boat, to the side of which they are attached by a long rope. The method of using them is as follows: If a stiff breeze is blowing, the boat is brought well up to the wind, or put under reefed sails, or both, if necessary, and the dredge is thrown overboard and sweeps the bottom. At short intervals the boat is brought to and the dredge is pulled up to a small adjustable board platform provided for the purpose, extending somewhat obliquely across the boat in front of the mainmast and supported on the center-board box (see plate XXXVII, *b*). The contents

* "Suggestions for the Employment of Improved Types of Vessels in the Market Fisheries," etc. By J. W. Collins. Bulletin of the United States Fish Commission, Vol. VIII, 1888, pp. 175–192. Washington, 1890.



SAIL AND SHEER PLAN OF BATTEAU.

Drawn by Captain R. H. Milligan.

of the scrape are dumped upon the board, and the crabs are separated with the hand from the mass of mud and grass in which they have been rolled by the movements of the boat. With a moderate wind the boats can sail under full headway.

The use of the dip-nets is easily understood. The men use their oar as a pole, pushing the boats slowly around the edges of the marshes, and in other shallow localities, and adroitly handle the net when a crab is seen.

The opinion prevails at Crisfield that the crabs are most active during the night and that they then frequent much shoaler water in larger numbers than during the day. The fishermen usually make their best catches shortly after daybreak, and there is sometimes considerable rivalry among them in making an early start to reach the shallows and put out their dredges for the crabs that during the night have come up to feed and moult.

Generally long before sunrise the harbor of Crisfield and the adjacent creeks and marshes are alive with the crabbing crafts. At 6 o'clock on the morning of August 14, 1888, 215 canoes and bateaux were counted between Crisfield and the mouth of the short river upon which it is located. As the sun shone upon their glistening sails of uniform size the sight was a striking one.

It is not an uncommon thing for an industrious crabber to return home to an early breakfast, having taken enough crabs by that time to satisfy him for the day. Ordinarily, however, the men remain out until the afternoon, putting in to the shore once or twice, perhaps, to unload their catch.

9. *The yield in* 1887 *and* 1888.—The daily catch varies considerably at different times, depending on the weather. A stormy period will not only cause the crabs to remain in the deeper water, but will also prevent the fishermen from following the fishery to any great extent. Taking the season through, however, the average daily catch to a boat in 1887 and 1888 was between 75 and 100 crabs, the former year being a rather more favorable one than the latter. While a large majority of the fishermen probably never exceeded these figures, except on rare occasions, a few, possessing energy and tact, did much better and for extended periods during each season took as many as 1,500 crabs weekly.

The total yield in 1887 was 2,199,931 crabs, and in 1888 3,928,308 crabs, an increase of 1,728,477 crabs. The value of the catch to the fishermen was $38,502 in 1887 and $69,743 in 1888. These figures would represent an average annual catch of about 3,300 and 5,000, respectively, to a man, or 4,000 and 6,275, respectively, to a boat. Although these averages are correct, they fail to show the fishery in the best light, since, in computing them, it has been necessary to include a considerable number of men and boats that were not steadily employed throughout the crabbing season. If deductions were drawn based simply upon the men who devoted themselves more or less regularly to the fishery, the results would be nearly doubled as compared with the foregoing figures.

10. *Disposition made of the catch.*—The fishermen do not ship their own crabs, but dispose of them to regular dealers, who pack the soft crabs for immediate shipment and place the "peelers" in floats provided for the purpose until the shedding process is over. As the fishermen bring in their crabs the dealers or their agents count them in the presence of the crabbers, separating the soft crabs, the "short-comers," and the "long-comers," and paying for them at the time in cash, or, as is the more general practice, giving a ticket or check, redeemable at any time.

The men usually sell their catch to particular dealers, whom they agree to furnish during the season.

11. *Prices to fishermen.*—Crisfield, as a crabbing town, has considerable competition among the fishermen of the upper Chesapeake, of Indian River and other localities in Delaware, of the Shrewsbury and other rivers in New Jersey, and of other places in the Middle States; and a large and constant supply of crabs in the principal markets is thus insured.

This condition tends to keep the prices low and also to prevent any marked fluctuations in them during a particular year.

From 1½ to 2 cents was the range of prices in 1887 and 1888. The soft crabs bring the same prices as those that are about to shed, while there is no sale for the hard crabs among the dealers in soft crabs. Soft crabs and "peelers" that die before reaching the hands of the dealers are of course unsalable.

B.—The Trade.

12. *Dealers, shipping-houses, etc.*—Twenty-five firms were engaged in buying, shedding, and shipping crabs at or near Crisfield in 1888.

The buildings occupied for packing crabs are plain frame structures, containing but one room, most of which are in the immediate vicinity of Crisfield, although a few are a short distance away, on the adjoining marshes. The houses vary in price from $50 to $500, about $100 being the average value. Some of them are constructed on piles, but the larger number of them are on land, and many have dirt floors.

From two to eight men form the complement of each shipping firm, the number in each house varying somewhat with the season and the amount of business transacted.

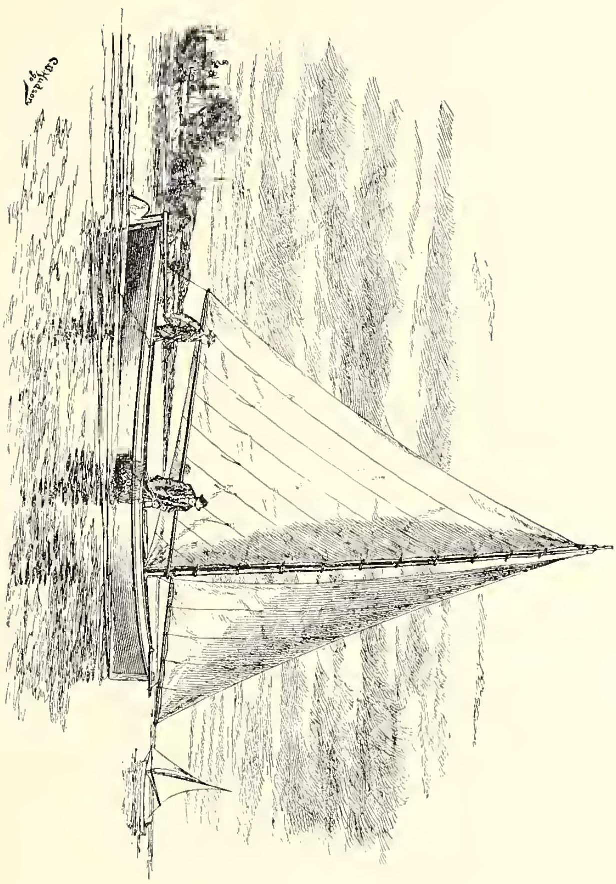
The outfit of the dealer is simple and the furnishing of the packing-houses are meager. All that is required to carry on the business are shipping-boxes, with trays; sea-weed and ice, in which to pack the crabs; and outside the houses, floats, in which the crabs are temporarily placed while shedding.

13. *The floats or pounds.*—These are made of light planks and scantling, with plain board bottoms and latticed sides. The size varies somewhat, but the largest number are 20 feet long, 3 to 5 feet wide, and 15 inches deep, with a projecting ledge at half their height, corresponding to the water-line (see plate XLIII). The average value of the floats is $2.

About 25 floats, each with an average capacity of three or four hundred crabs, is the usual quota of each dealer, but as many as 60 or 80 are owned by some of the larger shippers.

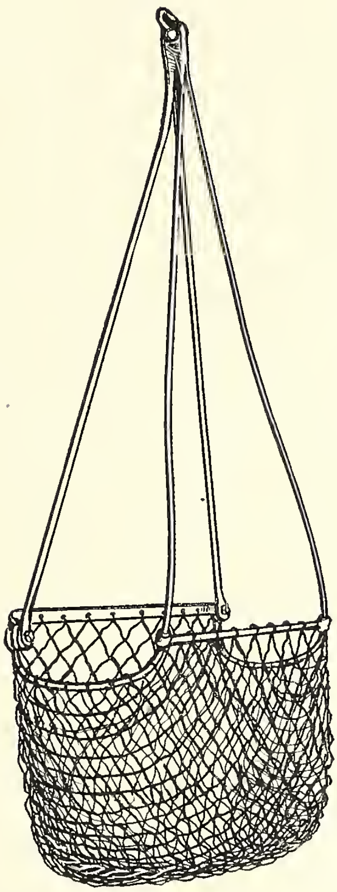
They are visited in boats three or four times daily, and the crabs that have shed since the last visit are taken out. The floats of each shipper are usually inclosed by a board fencing, which serves as a breakwater. This is considered necessary, as high waves would otherwise break over the pounds and swamp them. The inclosures of some of the shippers are an acre or more in area.

14. *Mortality of crabs.*—The one factor which, more than any other, tends to reduce the profits of the shippers, and indirectly the receipts of the fishermen, is the high death-rate among the impounded crabs. Owing to the injuries which many crabs receive in being caught and handled, and, in a measure, to the severity of the shedding process, a comparatively large number of crabs die after being purchased by the dealers, and are a total loss. As an illustration of the uncertainty of the business and of



DREDGING FOR CRABS. TYPICAL CHESAPEAKE CANOE. (See page 106.)

Drawn by C. B. Hudson.



CRAB DREDGE. (See page 106.)
Drawn by C. B. Hudson.

the risks which the dealers have to run at times, it may be stated that of 3,200 crabs purchased by a firm one day in July, 1888, no less than 3,000 died before shipment. This, of course, is an unusually great loss, and is not to be taken as a basis, although the individual dealers estimate their losses at from 10 to 30 per cent., and even as high as 50 per cent. during certain periods.

A few crabs die after leaving the hands of the shippers on the way to their destination, but this element of loss is being overcome by greater care and experience in packing the crabs prior to shipping them.

A comparison of the total catch with the aggregate shipments for 1888 gives a difference of 628,766 crabs, with a market value of about $23,600, which figures represent the mortality and consequent losses. The death-rate in 1887 was even higher than in 1888, being 21 per cent., as against 16 per cent. in the latter year. It is impossible to determine with accuracy the number of crabs which die during shipment to market, and this item is not taken into consideration in the foregoing statements.

There seems to be no remedy for this state of affairs. Although the season of 1888 showed a small but gratifying improvement over the previous year, it can hardly be hoped that the mortality will ever be reduced below a somewhat high limit, owing to the methods of capture and handling, and to the normal vicissitudes of the moulting process, increased as they are by the unnatural surroundings and conditions to which the crabs are subjected.

15. *Preparing crabs for shipment.*—The crates in which the soft crabs are packed for market are about 4 feet long, 1½ or 2 feet deep, and the same in width. They are provided with neatly fitting trays, in which the crabs are placed between layers of crushed ice and sea-weed. The capacity of the crates is from eight to ten dozen.

Soft crabs possess but little tendency to move, and when once packed in position, with their legs well folded up and their bodies placed obliquely, so that the moisture may not run from their mouths, they remain quiescent for a long time. This fact permits of the packing of a large number of crabs in a very small space.

16. *Markets.*—The principal markets to which the crabs are sent are New York, Boston, Philadelphia, Wilmington, Baltimore, and Washington. The larger part of the crabs are shipped by rail, but considerable quantities destined for Baltimore go by steamer. There is also a small but increasing demand among the inland towns of Pennsylvania and other States adjacent to Crisfield.

17. *Prices to dealers.*—The crabs are generally sold on commission, at prices varying with the supply and the demand. From 35 to 60 cents per dozen were the ruling rates in 1887 and 1888, although the average price was considerably higher in the former year, being 53 cents against only 40 cents in 1888. The enhancement in value was about $39,000 in 1887 and $43,000 in 1888, these amounts representing the gross profits of the dealers.

II.—THE HARD CRAB FISHERY AND TRADE.

A.—The Fishery.

18. *Relative importance of the fishery.*—Although hard crabs can be taken at Crisfield in almost unlimited quantities, the fishery for them is of comparatively little importance, as will appear from an inspection of the accompanying statistical tables. The

fishermen think that soft crabs are more remunerative and more certain of a ready sale than hard crabs, and for that reason the fishery for the latter is completely overshadowed by that for the former.

Only twelve men were regularly engaged in this fishery in 1887 and 1888, and the capital invested in boats and apparatus amounted to but $1,000, while the value of the crabs, at first hands, was only about $2,400.

19. *Fishing grounds.*—These are similar to those frequented by the soft-crab fishermen, but, as a rule, are not so far distant from Crisfield. At the present time by far the greater part of the catch of the regular crabbers is made in the Little Annemessex River, in close proximity to the town. Large fares are taken, and there has been no inducement to seek other but more distant grounds, which will be available should the supply nearer home become exhausted.

20. *Apparatus and methods of capture.*—While considerable quantities of hard crabs are taken with dip-nets and in the dredges of the soft-crab fishermen, the apparatus employed by the professional fishermen is set-lines, or "trot-lines," baited with tripe. The ends of the lines are buoyed or staked. In hauling them the men begin at one end and propel their boats along while carefully under-running the lines. The snoods to which the bait is tied are pulled up with caution, and the crabs which are clinging to the tripe are secured with a small dip-net. Usually but one man goes in a boat.

21. *Results of the fishery.*—The average catch of hard crabs per man is necessarily larger than in the soft crab fishery, owing to the more productive apparatus in use and to the greater facility with which the crabs are handled.

The total yield of hard crabs in 1887 and 1888 was 471,413 and 509,515, respectively, these being taken chiefly by regular hard-crab fishermen. Not an inconsiderable number were also obtained by irregular and soft-crab fishermen and sold to dealers, by whom they were shipped.

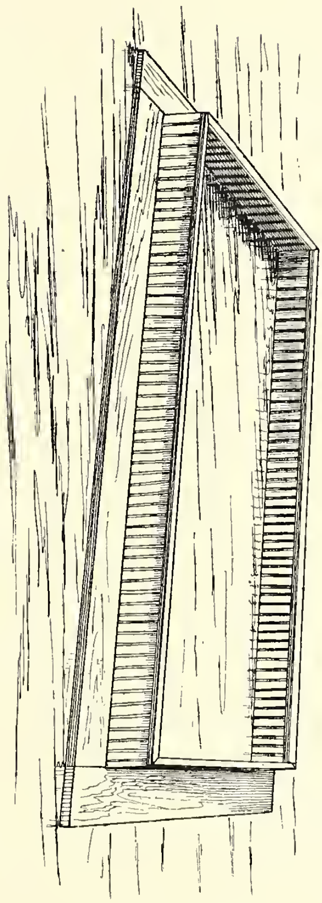
22. *Prices to fishermen.*—In 1887 and 1888 the price for hard crabs varied but little from 50 to 60 cents per hundred. This is not considered by the fishermen to be a sufficient inducement to abandon the fishery for soft crabs, for each of which from 1½ to 2½ cents are obtained. The principal hard-crab fishermen at Crisfield ship their own crabs, however, and are thus able to realize better prices.

B.—The Trade.

23. *Extent of trade.*—The handling and shipping of hard crabs at Crisfield is only incidental to the general trade in fishery products carried on by four dealers, except in the case of the hard-crabbers who send their own catch to market.

24. *Methods of shipment.*—Hard crabs do not require the care in packing and shipping which soft crabs need. They are simply crowded into large boxes and barrels, covered with wooden strips or sack-cloth, and shipped to their destination, usually without the use of ice or moist sea-weed. The mortality amounts to practically nothing.

25. *Markets and prices.*—Hard crabs are sent to the same markets to which the soft crabs are shipped. Owing to their hardiness they can also be sent for longer distances to many of the interior cities of the country. The average gross price received in 1887 and 1888 was 65 cents per hundred.



CRAB FLOAT OR POUND. (See page 108.)

III.—THE PREPARATION OF CRAB MEAT.

26. *Description of the process.*—Two of the fish firms already referred to are concerned in extracting the meat from the hard crabs and in shipping it in bulk to market, where it is chiefly used in hotels and restaurants.

Although of no great importance, it seems desirable to refer to this branch of the business in order to make the subject approximately complete.

The crabs are boiled for a few minutes in some large receptacle suited to the purpose, and when cool their shells are cracked and the meat is extracted by means of a small knife. From 60 to 75 crabs are usually reqnired to yield a gallon of the meat, although as few as 47 or 50 large crabs are sufficient. The meat is packed in tin buckets and shipped in ice.

27. *Persons employed.*—The crab-pickers are employed only at odd times and in no definite numbers. They are usually women, who hold themselves in readiness when the shippers have orders to fill. They become quite expert in the business, and strip a crab of its meat in a remarkably short time. They are not on wages, but are paid in proportion to the amount of work done.

28. *The yearly output.*—The demand for crab meat is as yet not extensive, and the quantity prepared annually is small and usually on contract. In 1888 about 27,000 crabs were utilized in this way, yielding 395 gallons of meat, valued at $1.20 per gallon. In 1887 the output was about 8 per cent. less than the following year.

IV.—STATISTICS.

The following tables show in detail the extent of the soft and hard crab fishery and trade at Crisfield in 1887 and 1888. The data were obtained by personal investigation and from actual records contained in the books of dealers and fishermen.

29.—*The fishery.*

Character of fishery.	Number of fishermen.		Boats.			
			1887.		1888.	
	1887.	1888.	No.	Value.	No.	Value.
Soft and peeler crabs	685	773	548	$22,400	626	$31,300
Hard crabs	12	12	12	900	12	900
Total	697	785	560	23,300	638	32,200

Character of fishery.	Value of apparatus of capture.		Crabs taken.			
			1887.		1888.	
	1887.	1888.	No.	Value.	No.	Value.
Soft and peeler crabs	$1,800	$2,100	2,199,931	$38,502	3,928,308	$69,743
Hard crabs	120	120	*471,413	2,359	*509,515	2,386
Total	1,920	2,220	2,671,344	40,861	4,437,823	72,129

* Including the crabs used in the preparation of crab meat.

30.—*The trade.*

Character of trade.	Persons employed		Value of shore property.		Floats or pounds.			
					1887.		1888.	
	1887.	1888.	1887.	1888.	Number.	Value.	Number.	Value.
Soft crabs	88	82	$2, 925	$3, 200	502	$990	578	$1, 060
Hard crabs	3	4	250	250	....	....	....	....
Total	91	86	3, 175	3, 450	502	990	578	1, 060

Character of trade.	Boats.				Crabs shipped.			
	1887.		1888.		1887.		1888.	
	No.	Value.	No.	Value.	Number.	Value.	Number.	Value.
Soft crabs	49	$867	50	$935	1, 821, 528	$81, 754	3, 299, 542	$108, 758
Hard crabs	...	....	....	....	446, 413	2, 883	482, 515	2, 973
Total	49	867	50	935	2, 267, 941	84, 637	3, 782, 057	111, 731

9.—REPORT OF EXPLORATIONS MADE IN MISSOURI AND ARKANSAS DURING 1889, WITH AN ACCOUNT OF THE FISHES OBSERVED IN EACH OF THE RIVER BASINS EXAMINED.

BY SETH EUGENE MEEK.

In July and August, 1889, the writer spent six weeks exploring the streams of the Ozark region of Missouri and Arkansas in the interest of the U. S. Fish Commission. The work was performed under the direction of Dr. David S. Jordan, and I received, throughout, the very efficient assistance of Mr. Louis Rettger and Mr. Frank M. Drew, students in the University of Indiana.

The region examined lies chiefly in southern Missouri and in western Arkansas. The surface of the country is much broken, although none of its hills reach any great height. The rock in place is chiefly limestone, containing much chert and flint. The flint breaks up into angular pieces which cover the bottom of the streams, affording lurking places to small fishes, but very destructive to the nets.

The Ozark region abounds in springs. The streams are clear and cold even in the heat of summer. The temperature rarely exceeds 76° Fah., and some streams are found as cold as 57° Fah.

Vegetation is not very abundant in the streams, being much less profuse than in the streams of western North Carolina and Virginia. The bottoms of the streams are rocky, gravelly, or sandy, with very little mud. Nearly all of those in Missouri are well filled with fishes, but there are fewer individuals than in streams seined by the writer in Iowa, Indiana, and the Carolinas. The greatest number of fishes was found near Mammoth Springs, but fishes were scarce in the Mazarn and especially so in the Caddo and in the forks of the Saline.

In collecting in these latter streams we were much disappointed. The fact that the country is thinly settled, and but a comparatively small amount of the timber has been cut, led us to believe that the fishes had been very little disturbed by man. We were informed by settlers to the west of Hot Springs that in the past few years many fishes in these streams have been destroyed by dynamite. The two summers previous to our visit many fishes were seen dead and dying along the Mazarn, Caddo, and the Saline. Dr. John C. Branner, director of the Geological Survey of Arkansas, informed the writer that large numbers of fishes were found dead along the forks of the Saline

in the summer of 1888. Whether this wholesale destruction is due to the use of dynamite I do not know. This is the explanation given by those living in the country, and those interested in preserving this valuable source of food.

We also heard elsewhere many complaints regarding the use of dynamite in capturing fishes, especially about Newburg, Mo., at Neosho, and at Cabool. At Neosho, we were informed by the superintendent of the United States Fish Hatchery that just before our visit several arrests had been made, and that heavy fines had been imposed upon a few persons for taking fishes by illegal methods. The Ozark streams are so abundantly supplied with springs that most of the small brooks never go dry in the summer, and the water in them is always cool. All streams seen by us seemed well adapted for fishes, but before good results can be obtained from stocking them by the United States or the State Commission, the wholesale use of dynamite in slaughtering the native fishes must be stopped.

In the present paper are given lists of the species taken in each stream together with such notes as seem useful. The species new to science are three, while a few others seem to present some varietal differences. I have also added to the paper the record of a few collections made in the same region in former years.

In the summer of 1886, Prof. R. E. Call, of Des Moines, Iowa, collected fishes in Dent and the neighboring counties in Missouri. In 1888, the writer collected a few fishes in Spadra Creek near Clarksville, Ark. The writer has been especially indebted to the assistance of Mr. Rettger and Mr. Drew while in the field, and he is also under obligations to Dr. D. S. Jordan and Dr. C. H. Gilbert for help in doubtful identifications, and for many valuable suggestions.

The new species described are as follows:

Zygonectes macdonaldi. Jones Creek and Osage Fork of the Gasconade.
Etheostoma juliæ. James River.
Notropis ozarcanus. North Fork of the White River.

I have also described two new subspecies:

Notropis telescopus arcansanus. Mammoth Spring.
Notropis atherinoides caddonis. Little Red and Caddo Rivers.

ITINERARY.

July 17.—The party met at St. Louis and took the train to Rolla.
July 18.—Collected in the Little Dry Fork of the Meramec River.
July 19.—Collected in Meramec Spring outlet, and in the Big Dry Fork of the Meramec River.
July 20.—Collected in Little Piney River near Newburg, Mo., and in the Meramec River near St. James, Mo.
July 22.—Collected in the Gasconade and Little Piney near Arlington, Mo.
July 23.—Went to Dixon, Mo.
July 24.—Collected in Jones Creek and the Marais River. Went to Marshfield, Mo.
July 25, 26.—Collected in the Osage Fork of the Gasconade and in the river near Marshfield, Mo.
July 27.—Went to Neosho, Mo.
July 29.—At Neosho.
July 30.—Collected in Hickory Creek and Shoal Creek, and went to Springfield, Mo., same evening.
July 31.—Collected in the James River and the Sac River near Springfield, Mo.
August 1, 2.—Went to Mansfield. Collected in the Lock Fork of the Gasconade and in Bryant's Creek. Went to Cabool, Mo.
August 3.—Collected in Big Piney, and the North Fork of the White near Cabool; went to Mammoth Spring, Ark.

August 4.—The rain of the previous day and the two previous nights had swollen the streams so that fieldwork was impossible.

August 5.—Collected in Spriug Branch near Mammoth Spring, Ark.

August 6.—Collected in Myatt and English Creeks, near Mammoth Spring, Ark.

August 7.—Collected in Spring River and in Warm Fork of Spring River, near Mammoth Spring, Ark.

August 8.—Went to Hot Springs, Ark.

August 9-11.—Packed collections, mended nets, and prepared to go west with team.

August 12-16.—Spent in traveling and collecting west of Hot Springs.

On this trip we collected in Mazarn and Myers Creeks, in the Caddo and two tributaries, in the South Fork of Ouachita River near Mount Ida, and in the Ouachita River near Crystal Springs.

August 18.—Collected in the West and Middle Forks of the Saline, about 25 miles west of Hot Springs, Ark.

August 19.—Went to Judsonia, Ark.

August 20.—Collected in a small tributary of the Little Red River, near Judsonia, Ark.

August 21.—Returued to Bloomington, Ind.

The streams examined may be classified as follows:

A.—Missouri River Basin.

- I.—Meramec River:
  1. Meramec River, St. James, Mo.
  2. Meramec Spring, 5 miles southeast of St. James.
  3. Big Dry Fork, near St. James.
  4. Little Dry Fork, near Rolla.
- II.—Gasconade River:
  1. Gasconade River, at Arlington, Mo.
  2. Gasconade River, 5 miles above Arlington.
  3. Little Piney River at Newburg and Arlington.
  4. Osage Fork of the Gasconade River, 6 miles southeast of Marshfield.
  5. Lock Fork of the Gasconade at Mansfield.
  6. Big Piney River at Cabool.
  7. Jones Creek near Dixon.
- III.—Osage River:
  1. Marais River near Dixon, Mo.
  2. Niangua River near Marshfield.
  3. Sac River near Springfield, Mo.

B.—Arkansas River Basin.

- IV.—Neosho River:
  1. Shoal Creek near Neosho, Mo.
  2. Hickory Creek near Neosho.
  3. Spring Branch of Hickory Creek.
- V.—Spadra Creek, Clarksville, Ark.

C.—White River Basin.

- VI.—White River in Missouri:
  1. James River near Springfield.
  2. Bryant's Creek near Mansfield.
  3. North Fork of White River, south of Cabool.
- VII.—Tributaries of White River about Mammoth Spring, Arkansas:
  1. Mammoth Spring.
  2. Spring River at Mammoth Spring.
  3. Warm Fork of Spring River.
  4. English Creek, west of Mammoth Spring.
  5. Myatt Creek, 6½ miles southwest of Mammoth Spring.
- VIII.—Little Red River:
  1. Little Red River at Judsonia, Ark.

D.—Washita River Basin.
- IX.—Washita or Ouachita River:
  1. Washita River at Crystal Springs, Ark.
  2. Caddo River at Caddo Gap and Black Springs.
  3. South Fork of the Ouachita at Mount Ida.
  4. Mazarn Creek near Myers, Ark.
  5. Myers Creek near Myers.
  6. West Fork of Saline River, 24 miles west of Hot Springs.

A.—BASIN OF THE MISSOURI RIVER.

I.—THE MERAMEC RIVER.

The *Meramec River* rises near the southern border of Dent County, Mo. Its course is northeasterly, and it empties into the Mississippi River about 40 miles south of the Missouri River. The Meramec, together with many of its southern and western tributaries, have their origin in a considerably elevated portion of the Ozark Mountains, and in a cherty limestone region which is well supplied with springs.

We visited the Meramec River near St. James, Mo. At this point it is a beautiful stream of clear water flowing over a bottom of shingle and sand. The water was quite low on account of dry weather. In places the river was less than 40 feet wide and less than 4 feet deep. The river shows evidence of being a torrent in times of high water, and containing many times the volume of water it had during our visit.

The Meramec Spring is about 5 miles south and east of St. James. It is one of the largest springs in Missouri. The water flows from a large fissure at the foot of a cliff, and forms a stream larger than the Meramec River itself at the time of our visit. The spring is about 1 mile from the river; its outlet contains much vegetation, and its bottom for the most part is muddy. The left side of the Meramec River, below the mouth of the spring outlet, has a muddy bottom, and contains much vegetation. The temperature of the water at the spring was 56° Fah. About 100 rods below the spring the temperature was 57° Fah. More than fifty years ago a dam was thrown across the spring outlet, near the spring, and a portion ot the water was used to run the machinery of an ironworks having sufficient capacity to furnish employment for about one hundred men. The motor used was a large breast-wheel. The water from the spring is very clear.

The Big Dry Fork of the Meramec River was visited between St. James and the Meramec Spring, and the Little Dry Fork near Rolla, Mo. In these two streams the currents are sluggish, and the bottom is more or less muddy, with occasional stretches of sand and gravel. At the time we were there the streams were not much more than a series of deep holes, with little running water between them. The temperature of Big Dry Fork was 85° Fah.; of Little Dry Fork, 79° Fah.

1. **Ammocœtes branchialis** (Linnæus).

One larval specimen was taken from among the weeds in the Meramec River a short distance below the mouth of the Meramec Spring outlet.

2. **Ameiurus natalis** (Le Sueur).

Anal rays, 24 to 25; base of anal, 3½ in the length of the body. Three specimens from Little Dry Fork.

3. Noturus exilis Nelson.

Anal rays, 15 to 17; head, $4\frac{1}{2}$ in length of body; depth, 7. Dorsal, anal, and caudal fins each with a narrow, dusky border. Little Dry Fork; common.

4. Catostomus nigricans (Le Sueur).

Meramec River, scarce; Meramec Spring, Big Dry Fork, not common.

5. Catostomus teres (Mitchill).

Abundant in the Meramec Spring outlet. A few specimens were taken from the Meramec River and the Little Dry Fork.

6. Minytrema melanops (Rafinesque).

Dorsal rays, 12; scales, 45 to 46; depth, $4\frac{1}{2}$; Meramec Spring outlet; common.

7. Moxostoma duquesnei (Le Sueur).

Scales 46 to 48 in specimens from Meramec Spring Outlet. Meramec Spring, very abundant; less common in the Meramec River and the Little and Big Dry Forks.

8. Campostoma anomalum (Rafinesque).

Tubercles on the head and body, on some specimens from the Meramec Spring. Very abundant in Meramec River and Spring; scarce in Big and Little Dry Forks.

9. Chrosomus erythrogaster Rafinesque.

Males from Spring Outlet with much red on sides and belly. Abundant in Meramec Spring Outlet; one specimen from the Big Dry. This species abounds in clear, cool water.

10. Hybognathus nubila (Forbes).

Below eye, at base of pectoral, ventral, anal, and caudal fins faint red on males. All specimens have a dark lateral band; no black spot at base of caudal fin. Scales 35 to 38. Origin of first dorsal ray slightly nearer tip of snout than base of the caudal. Very common in the Meramec River; scarce in the Little Dry Fork.

11. Pimephales notatus (Rafinesque).

Meramec River and Big Dry Fork; scarce.

12. Notropis cayuga Meek.

Mouth small, its gape nearly horizontal; snout blunt, its length $3\frac{4}{5}$ in length of head. Eye rather large, its diameter $2\frac{3}{4}$ to 3 in head. Head $4\frac{1}{4}$ in length of body; depth $4\frac{1}{2}$ to $4\frac{3}{4}$. Back slightly elevated. Dorsal fin slightly nearer tip of snout than base of caudal fin. Thirteen scales before dorsal, 37 scales in the lateral line. Color, olivaceous, paler below. Sides with a dusky band, consisting of small dark dots; the band extending on snout of the upper lip only. Meramec River, scarce.

13. Notropis boops Gilbert.

(*Notropis scabriceps* Jordan & Gilbert, Proc. U. S. Nat. Mus., 1885, 3; not of Cope.)

Scales in the lateral line 35 to 36. Head $4\frac{1}{5}$; depth $4\frac{1}{4}$ to $4\frac{3}{5}$. Eye very large, its diameter $2\frac{1}{2}$ in head. Teeth 1—4—4—1: tips hooked, no evident grinding surface, edges crenate Big Dry Fork, abundant; Meramec River and Little Dry Fork, scarce.

14. Notropis whipplei (Girard).

Big Dry Fork, not common.

15. Notropis megalops (Rafinesque).

Scales on the anterior part of body little if any smaller than those on rest of body. This is true of all specimens taken by us in the Missouri and Arkansas. Thirteen to 17 scales in front of dorsal fin. Sides silvery, with a darkish plumbeous band, less conspicuous than in *N. zonatus*. The young of this species and of *N. zonatus* appear very much alike.

16. **Notropis zonatus** (Agassiz).

Head 4 in the length of the body, depth 4½ to 5½. Sides with a dark plumbeous band, above which is usually a more narrow silver band; upper part of body dusky; a dark vertebral line; a dark band on shoulder from upper edge of opercle to base of pectoral fin. Lower part of body and the lower fins on males with some red. The position of the dorsal fin is variable; in some specimens it is midway between tip of snout and base of caudal fin; in others the middle of the fin is midway between base of caudal fin and tip of snout. It is usually further forward on the larger and deeper specimens.

This species is very abundant in southern Missouri. It prefers cool, clear water, and is usually taken with *N. megalops*. Its colors are brighter when taken from streams with clear, cool water. It is one of the largest, handsomest, and most graceful of the species of *Notropis*. Meramec River and Spring Outlet, abundant.

17. **Notropis umbratilis cyanocephalus** (Copeland).

First dorsal ray midway between the eye and caudal fin. Body deep, compressed. Color pale greenish in life, with more or less pinkish on the sides. All specimens taken were less than 2½ inches in length. A dark vertebral line and a dark spot at base of dorsal in front. Big and Little Dry Forks, abundant.

According to the studies of Dr. Gilbert, *Notropis ardens*, *cyanocephalus*, *atripes*, *lythrurus*, *matutinus*, and *nigripinnis* are indistinguishable as species from *N. umbratilis*.

18. **Notropis rubrifrons** (Cope).

Head 4⅓ to 4½ in the length of the body; depth 5 to 5½; scales 40 to 42 in the lateral line. Eye small, scarcely equal to length of snout, its diameter 3½ in length of head in specimens 2½ inches in length. A broad, high plumbeous band on sides overlaid with silvery; lateral line decurved, usually forming lower boundary of the plumbeous band. Some red on the lower parts of the body on some specimens. Anal rays 9 or 10, usually 10. Meramec River and Little Dry Fork, common; Big Dry Fork, scarce.

19. **Notropis lutrensis** (Baird and Girard).

Big Dry Fork.

20. **Hybopsis amblops** (Rafinesque).

Big Dry Fork, scarce.

21. **Hybopsis kentuckiensis** (Rafinesque).

Meramec River, Big and Little Dry Forks, common.

22. **Semotilus atromaculatus** (Mitchill).

Meramec Spring and Little Dry Fork, not common; Big Dry Fork, scarce.

23. **Notemigonus chrysoleucus** (Mitchill).

Little Dry Fork, one specimen.

24. [**Salmo irideus** Gibbons.

This species is not native to the Ozark region. It has been introduced into the streams in Missouri by the Missouri State fish commission. Several specimens were taken by us in the Meramec Spring Outlet.]

25. **Fundulus catenatus** (Storer).

Usually with few crimson spots on opercles and sides of the body. The lateral stripes are much broken in some specimens. A few faint dark vertebral bars are quite conspicuous on the posterior portion of the body. The dorsal fin is larger in adult males than in females. Meramec River, common; Big Dry, scarce.

26. Zygonectes notatus (Rafinesque).

Big Dry Fork, one specimen.

27. Lucius vermiculatus (Le Sueur).

Branchiostegals, 11 to 13. Lateral line, 105. Meramec Spring Outlet, common; Meramec River, scarce. Taken among weeds. Specimens all small.

28. Labidesthes sicculus Cope.

Big Dry, one specimen.

29. Ambloplites rupestris (Rafinesque).

Meramec River, one specimen. Taken by hook and line.

I was informed that the Meramec River at the mouth of the Spring Outlet used to be an excellent place to catch Black Bass (*M. salmoides* and *M. dolomieu*), "Croppies" (*A. rupestris*), and other species of sun-fish, with hook and line. About 6 miles below the Spring Outlet a dam was built across the Meramec River. Since then there has been a noted scarcity of the game fishes at this point. The dam was built about four years ago. No fishway has been erected at the dam.

30. Lepomis cyanellus Rafinesque.

Big and Little Dry Forks, scarce.

31. Lepomis pallidus (Mitchill).

Big and Little Dry Forks, scarce.

32. Micropterus dolomieu Lacépède.

Meramec Springs, Meramec River, and Big Dry Fork, not abundant.

33. Micropterus salmoides (Lacépède).

Meramec River, one specimen taken.

34. Etheostoma nigrum Rafinesque.

Scales in the lateral line, 52 to 54. Dorsal spines, 10 in one specimen; soft rays, 12. Meramec River and Big Dry Fork, scarce.

35. Etheostoma blennioides Rafinesque.

Depth 5 to 5½, more slender than eastern forms. Meramec River, Big Dry Fork, and Little Dry Fork, scarce.

36. Etheostoma cœruleum Storer.

One specimen from Little Dry Fork has the dorsal XII—13, others with IX—XI spines in the dorsal. Scales, 43 to 48. Several specimens taken are of the *spectabile* form. The markings on some of the larger females are irregular, giving them a marbled appearance. Meramec River and Little Dry Fork, not common.

37. Etheostoma zonale (Cope).

Meramec River, one specimen; scales in lateral line 49.

38. Cottus bairdi Girard.

Dorsal spines, 6 to 8; soft rays, 17 to 18. Color, variable. Some specimens very dark, with no markings; others reticulated with dark; others plain olive; dark bars present on a few specimens. Meramec Spring, abundant; Meramec River, common; Little Dry Fork, scarce.

II.—The Gasconade River Basin.

The headwaters of the *Gasconade* are farther west and south than those of the Meramec River. The river flows in a northeasterly direction and empties into the Missouri River about 30 miles below the mouth of the Osage River. We visited the Gasconade

at Arlington, Mo., and at a point 5 miles higher. Here it is a clear stream flowing for the most part over a gravelly and sandy bottom. The river is about 125 yards wide and at times of low water easily forded. Vegetation in the river was scarce, and but few fishes were taken in each haul of the seine. The temperature was 80° Fah.

Little Piney River is an eastern tributary of the Gasconade. It is a clear stream of water flowing with a considerable current. The bottom is sandy and gravelly with scarcely any mud except near its mouth, which is at Arlington. In times of low water the stream between Arlington and Newburg, Mo., seldom exceeds 20 or 30 feet in width. The stream is largely fed by springs, and is said always to contain considerable running water. Our seining was done at Newburg and at Arlington, Mo. The supply of smaller fishes was quite large. Larger fishes are taken in small numbers in the larger holes. The temperature of Little Piney at Newburg was 76°; at Arlington, near its mouth, 79°.

The Osage Fork of the Gasconade.—This stream was visited about 6 miles southeast of Marshfield, Mo. It is a sluggish stream, some 50 feet wide in the broadest places. In the deeper places the bottom was muddy, elsewhere somewhat rocky. The water was not clear at the time of our visit, while the waters of the Niangua visited the previous day were very clear. The temperature was 97° Fah.

The Lock Fork of the Gasconade.—This stream was examined at Mansfield, Mo. It is nearly twice the size of the Osage Fork, its waters clearer, and the bottom with much less mud. Otherwise it is much like the Osage Fork. This stream is seined a great deal by the people living on its banks near Mansfield. Large cat-fish are said to be taken frequently. Not many fish were obtained by us. The temperature was 78° Fah.

Big Piney River was visited near Cabool, Mo. It is here a small stream, with a rather sluggish current and a stony bottom. Near Cabool the stream widens until it is about 60 to 100 feet wide and from 2 to 10 feet deep. Fish are apparently scarce in this stream. The scarcity is in some measure due to the presence of gristmills and sawmills, which discharge refuse substances into the stream, and to the use of dynamite. It is reported that dynamite is frequently used in this region. The temperature was 74° Fah.

Jones' Creek is a small stream near Dixon, Mo. It is little more than a small brook, seldom exceeding 30 feet in width. It has a rocky and gravelly bottom, with occasional stretches of sand. Temperature 76° Fah.

1. **Noturus exilis** Nelson.

Dorsal and caudal fins tipped with black. Common in Jones' Creek; a few specimens from Little Piney.

2. **Leptops olivaris** (Rafinesque).

A few specimens were seen in the market at Newburg, Mo. They were reported to be from the Gasconade.

3. **Ameiurus melas** (Rafinesque).

Two specimens from the Big Piney. Color, silvery; the distal half of each anal ray black, the rest of each ray the color of the body.

4. **Ameiurus nebulosus** (Le Sueur).

One specimen from the Osage Fork of the Gasconade. Anal rays, 22.

5. **Ictalurus punctatus** (Rafinesque).

A few specimens seen in the Newburg market, from the Gasconade.

6. **Catostomus nigricans** Le Sueur.

Found in all places except the Big Piney; common.

7. **Catostomus teres** Mitchill.

Big Piney; not common.

8. **Moxostoma duquesnei** Le Sueur.

Common in the Osage Fork and the Big Piney; not common in the Lock Fork; scarce in the Little Piney and Gasconade at Newburg and Arlington.

9. **Campostoma anomalum** (Rafinesque).

Abundant in Jones' Creek and Big Piney; scarce in the Osage and Lock Forks of the Gasconade.

10. **Chrosomus erythrogaster** Rafinesque.

Osage Fork, Big Piney, and Jones' Creek, common.

11. **Hybognathus nubila** (Forbes).

Scarce in Little Piney; abundant in Jones' Creek, the Lock and Osage Forks of the Gasconade. A black spot at base of caudal fin.

12. **Pimephales notatus** (Rafinesque).

Osage and Lock Forks, abundant; Big Piney, common; Little Piney, scarce.

13. **Notropis cayuga** Meek.

This species is very scarce in southern Missouri. It is usually found in quiet and warm waters. Big Piney, Osage, and Lock Forks of the Gasconade.

14. **Notropis boops** Gilbert.

At the base of the caudal fin is a distinct <-shaped spot, the apex pointing towards the head of fish, the first dorsal ray nearer base of caudal than tip of the snout. Eye 3 in head, head 4 in length, depth $4\frac{1}{4}$. The specimens of this species from the Gasconade and Little Piney differ from those from the Big Dry, at Rolla, Mo., in having the <-shaped blotch at base of caudal, in the smaller eye, and the more posterior position of the dorsal fin. Abundant in the Little Piney and the Gasconade near the mouth of Little Piney; Jones' Creek, scarce.

15. **Notropis lutrensis** (Baird & Girard).

Two specimens from the Little Piney. Snout tuberculate; head, $3\frac{3}{4}$; depth, $3\frac{1}{8}$. First dorsal ray midway between snout and base of the caudal fin. Color, steel-bluish.

16. **Notropis whipplei** (Girard).

Abundant near the mouth of the Little Piney; scarce in the Osage Fork of the Gasconade.

17. **Notropis zonatus** (Agassiz).

Usually a scarlet red band across the middle of the dorsal fin in the males. Some specimens from the Big Piney are very slender, the depth being $5\frac{1}{2}$ in the length. The position of the dorsal fin is farther back in the more slender specimens. The clearer and cooler the water in which this minnow is found the brighter are its colors. Big Piney, Little Piney, Gasconade, Lock Fork, Osage Fork, and Jones' Creek; common.

18. **Notropis megalops** (Rafinesque).

Big Piney, common; Lock Fork of the Gasconade, common.

19. **Notropis umbratilis cyanocephalus** (Copeland).

Abundant from the Lock and Osage Fork of the Gasconade. The larger specimens are much compressed. Color, dark bluish, dark spot at base of dorsal in front.

The smaller specimens are less compressed, more slender, and the color much lighter. Longest specimen, 3 inches.

20. **Notropis rubrifrons** (Cope).

Very common in the Osage Fork, scarce in the Lock Fork, not common in the Little Piney. Anal rays 10, occasionally 9 or 11.

21. **Hybopsis kentuckiensis** (Rafinesque).

Abundant in all streams.

22. **Hybopsis dissimilis** (Kirtland).

Gasconade and Little Piney, scarce.

23. **Semotilus atromaculatus** (Mitchill).

Rather scarce in all streams.

24. **Dorosoma cepedianum** (Le Sueur).

One specimen from Little Piney, near its mouth.

25. **Fundulus catenatus** (Storer).

Scarce in Jones' Creek and the Gasconade; abundant in the Little Piney.

26. **Zygonectes macdonaldi**, sp. nov. (Plate XLII, fig. 1).

Closely allied to *Zygonectes sciadicus* (Cope), but with larger anal fin, more slender body, and rather stronger teeth. (A. 10 to 11 in *Z. sciadicus*.) Length of longest specimen, $2\frac{1}{2}$ inches; head, $3\frac{3}{5}$ in the length of the body; depth, $4\frac{1}{2}$ to 5; dorsal, 10 or 11; anal, 12 to 14. Origin of dorsal behind origin of the anal. Scales large, 34 to 36 (the small ones at base of caudal not counted), 12 in a vertical series. Body rather long and slender, not much compressed; top of head flat; back slightly arched. Teeth rather large in one series, each curved inwards. Ventrals very small, and situated midway between pectoral and anal fins. Dorsal fins small; anal larger. Caudal fin rather large, rounded. Color greenish in spirits, no distinct markings, darker on upper portion of the body; both jaws more or less edged with blackish.

Four specimens were taken from Jones' Creek and five from the Osage Fork of the Gasconade. Larger specimens, described further on, were obtained in the Neosho River. I take pleasure in naming this pretty fish for the United States Commissioner of Fisheries, Hon. Marshall McDonald.

27. **Labidesthes sicculus** Cope.

Abundant in Big Piney and the Osage Fork of the Gasconade. This species is found in greatest numbers in rather warm sluggish water.

28. **Lepomis cyanellus** (Rafinesque).

Not common; Jones' Creek, Gasconade, Big Piney, and Little Piney.

29. **Lepomis macrochirus** Rafinesque.

Lepomis nephelus Cope, Jour. Acad. Nat. Sci. Phila., 1868, 222.
Lepomis ischyrus Jordan & Gilbert, Syn. Fish N. A., 1883, 475.
Lepomis macrochirus Jordan & Gilbert, Syn. Fish. N. A., 1883 (probably *Lepomis macrochirus* of Rafinesque).

Head 2 in the length of the body; in specimens 4 inches in length; 3 in specimens $2\frac{3}{4}$ inches. Depth, $2\frac{1}{2}$. Scales, 45 to 51. D. X, 11 or 12. Dorsal spines in one specimen 9. Body more compressed than in *L. cyanellus*. Supplemental bone well developed. Mouth nearly as large as in *L. cyanellus*. Cheeks with 5 rows of scales. Color as in adult *L. pallidus*, but darker and much more mottled with distinct bronze spots, these on dorsal and anal fins. Usually a faint dark spot on last dorsal rays.

Three specimens from Osage Fork of the Gasconade, more abundant in Lock Fork of the Gasconade.

30. **Lepomis pallidus** (Mitchill).

Little Piney, Big Piney, Gasconade, and Osage Fork.

31. **Lepomis megalotis** Rafinesque.

Osage Fork of the Gasconade, one specimen.

32. **Micropterus dolomieu** Lacépède.

Gasconade, Little Piney, and Osage Fork, rather common.

33. **Micropterus salmoides** (Lacépède).

Scarce in the Pineys and the Osage Fork; common in the Lock Fork of the Gasconade.

34. **Etheostoma nigrum** Rafinesque.

Lock Fork of the Gasconade, one specimen.

35. **Etheostoma blennioides** Rafinesque.

Lock Fork, Osage Fork, Little Piney, and Gasconade, scarce.

36. **Etheostoma uranidea** Jordan & Gilbert.

Gasconade and Little Piney, two specimens.

37. **Etheostoma caprodes** Rafinesque.

Osage Fork and Lock Fork of the Gasconade, scarce.

38. **Etheostoma aspro** (Cope & Jordan).

Gasconade and Little Piney, not common.

39. **Etheostoma cymatotænia** Gilbert & Meek.

Cheeks and opercles scaly, scales 71 in one specimen from Osage Fork. D. XII, 12. One specimen from Little Piney and one from the Osage Fork.

40. **Etheostoma flabellare** Rafinesque.

Jones Creek, Little Piney, and Osage Fork.

41. **Etheostoma punctulatum** (Agassiz).

Jones Creek, Big Piney, Osage Fork, and Lock Fork, scarce.

42. **Etheostoma cœruleum** Storer.

Found in all streams, but much less common than the following. The color is much mottled on some female specimens. Dorsal spines 10 to 11.

42*b*. **Etheostoma cœruleum spectabile** (Agassiz).

Found in all streams, but in much larger numbers than *E. cœruleum*. Dorsal spines 9 to 11. This and the preceding form grade into each other.

43. **Etheostoma microperca** Jordan & Gilbert.

One specimen from Jones' Creek; not different from specimens from Indiana.

44. **Cottus bairdi** Girard.

Common in the Big Piney; less common in the Little Piney; scarce in the Osage and Lock Forks, and in Jones' Creek.

III.—THE OSAGE RIVER.

The tributaries of this river visited were the Marais, the Niangua and the Sac.

The *Marais River* near Dixon, Mo., is a rather small stream which empties into the Osage near its mouth. It was visited in time of low water and was found to consist of long deep holes with little running water between them. The bottoms of the

deep holes were muddy, the spaces between them rocky and gravelly. A small bayou near the river was also seined. It yielded only *Notemigonus* and *Ameiurus* in abundance. The river is fed by a few small streams only. The waters were muddy in consequence of the rain preceding and during our visit. The temperature was 77° Fah.

The *Niangua River* near Marshfield, Mo., is a stream of very clear water flowing over a sandy and gravelly bottom. When we visited it the water was low, and in many places the stream was not more than 20 feet wide. The Niangua is fed by numerous quite large springs found all along its course. This stream is quite remarkable for the bright colors of its minnows and darters. A great number of *Etheostoma cœruleum spectabile* were taken from a sort of bayou with a sandy and muddy bottom. The temperature of the Niangua was 76° Fah. The Pomme de Terre River rises near Marshfield, Mo. It is some 10 miles distant. We were told that during the summer it runs nearly dry, and that it was in this condition when we were there. Owing to these facts we did not visit it.

The *Sac River* near Springfield is not large, and the water is not very clear. The bottom has mud, some sand and gravel, and the current is rather sluggish. It is much smaller than the James, and according to the people of Springfield it bears no comparison to the James for fishing purposes, although the James is said to be quite depleted of its game fishes. The temperature of the Sac was 79° Fah.

1. **Noturus exilis** (Nelson).

   The Niangua. Scarce.

2. **Ameiurus melas** (Rafinesque).

   One specimen from the Marais. Common in the small bayou near the Marais.

3. **Ictiobus cyprinella** (Cuvier & Valenciennes).

   One specimen from the Marais.

4. **Ictiobus bubalus** (Rafinesque).

   One specimen from the Marais.

5. **Catostomus teres** (Mitchill).

   Common in the Niangua and the Marais.

6. **Catostomus nigricans** Le Sueur.

   Common in the Niangua and the Marais; not common in the Sac.

7. **Moxostoma macrolepidotum duquesnei** (Le Sueur).

   Niangua and the Marais; not common.

8. **Campostoma anomalum** (Rafinesque).

   Very common in the Niangua and the Sac. Three specimens from the Marais.

9. **Chrosomus erythrogaster** Rafinesque.

   Abundant in all three streams.

10. **Hybognathus nubila** (Forbes).

    Very abundant in all three streams.

11. **Pimephales notatus** (Rafinesque).

    Common in the Niangua and Sac, more abundant in the Marais.

12. **Notropis cayuga** Meek.

    Six specimens from the Niangua.

13. **Notropis deliciosus** (Girard).

    One specimen from the Sac River.

14. **Notropis lutrensis** (Baird & Girard).
Eight specimens from the Marais.

15. **Notropis zonatus** (Agassiz).
Abundant in all three streams. The specimens taken from the Niangua were more brightly colored than any other specimens of the same species taken during the summer.

16. **Notropis umbratilis** (Girard).
The typical form of this species is common in the Marais and the Sac. The scales vary from 40 to 48. A few specimens are much compressed, others less so. All belong, however, to the same species. The black spot at front of dorsal is not large.

17. **Notropis rubrifrons** (Cope).
One specimen from the Sac.

18. **Hybopsis kentuckiensis** (Rafinesque).
Abundant in all streams.

19. **Semotilus atromaculatus** (Mitchill).
Common in the Niangua. One specimen from the Marais and three from the Sac.

20. **Notemigonus chrysoleucus** Mitchill.
This species was abundant in a small bayou a short distance from the Marais. It was not found in any of the streams.

21. **Labidesthes sicculus** Cope.
Marais, Niangua; scarce.

22. **Lepomis cyanellus** Rafinesque.
Few specimens from the Niangua and the Marais.

23. **Lepomis humilis** (Girard).
Five specimens from the Marais.

24. **Micropterus dolomieu** Lacépède.
Two specimens from the Marais.

25. **Etheostoma nigrum** Rafinesque.
Abundant in the Niangua; three specimens from the Marais.

26. **Etheostoma blennioides** Rafinesque.
Marais and Sac, scarce.

27. **Etheostoma flabellare** Rafinesque.
Niangua and Marais, scarce.

28. **Etheostoma punctulatum** (Agassiz).
Niangua, common.

29. **Etheostoma nianguæ** Gilbert & Meek.
Dorsal spines 12, scales 78. In one specimen the lateral line is incomplete on one side. Niangua River, three specimens taken.

30. **Etheostoma cymatotænia** Gilbert & Meek.
Marais, two specimens.

31. **Etheostoma cœruleum** Storer.
Few specimens of this form taken from each stream.

Var. *spectabile* Agassiz was very abundant in all streams, especially so in the Niangua. The largest number was taken from still water with sandy and muddy bottom.

32. **Cottus bairdi** Girard.
Niangua, common; Marais and Sac, scarce.

B.—BASIN OF ARKANSAS RIVER.

IV.—THE NEOSHO RIVER.

The *Neosho River*, in southeastern Kansas and southwestern Missouri, is a tributary of the Arkansas. *Shoal Creek*, the stream examined, is a rather large creek, near the town of Neosho. It has a depth of more than 6 feet, except in occasional shallow places where the water flows rapidly over a gravelly bottom. In the rapidly flowing places the water is quite clear, but opaque in the deeper places. The bottom is rather muddy in the deeper places. The width of the stream varies from 100 to 150 feet. The temperature is 76° Fah.

Hickory Creek, a small tributary of Shoal Creek, has a temperature of 74°. The temperature of a spring branch of Hickory Creek was 66½°.

The U. S. Fish Commission has built a fish hatchery at Neosho. At the time of our visit no hatching had been done. Several ponds had been made and the building was nearly finished. The hatchery is supplied with water from a beautiful, but not large spring.

1. **Noturus exilis** Nelson.
   A few specimens taken from the spring branch.
2. **Catostomus teres** (Mitchill).
   Common.
3. **Catostomus nigricans** Le Sueur.
   Apparently scarce.
4. **Moxostoma duquesnei** (Le Sueur).
   Common.
5. **Campostoma anomalum** (Rafinesque).
   Common.
6. **Hybognathus nubila** (Forbes).
   Abundant.
7. **Pimephales notatus** (Rafinesque).
   Abundant.
8. **Notropis galacturus** (Cope).
   Not common.
9. **Notropis megalops** (Rafinesque).
   Very common.
10. **Notropis zonatus** (Agassiz).
    Abundant.
11. **Notropis rubrifrons** (Cope).
    Common.
12. **Hybopsis kentuckiensis** (Rafinesque).
    Common.
13. **Hybopsis amblops** (Rafinesque).
    A few specimens taken.
14. **Semotilus atromaculatus** (Mitchill).
    One specimen taken.
15. **Zygonectes macdonaldi** Meek.

Numerous specimens of this species are in the aquarium of the United States Fish Commission at Washington, having been sent in from the hatchery at Neosho. These are larger than the original types, and show the following characters:

Form of *Zygonectes notatus;* the tail rather deeper. Head $3\frac{4}{5}$ in length; depth $4\frac{1}{5}$. Scales 38—13 or 14. D. 10 to 12. A. 14 or 15. Eye $3\frac{2}{3}$ in head, slightly longer than snout. Mouth large, the chin projecting; outer series of teeth very strong, hooked; lower jaw equal to eye. Pectoral small, $1\frac{1}{2}$ in head. Caudal broad; anal large, higher and longer than dorsal. Color in life, olivaceous, with a very faint broad lateral shade of darker; scales centrally bluish, their edges yellow. Adult with the caudal broadly edged with scarlet above and below; more or less red on upper part of dorsal and lower part of anal; faint olivaceous spots on bases of dorsal, anal, and caudal. No cross bars in either sex; no dark spots on scales or below eye.

16. **Labidesthes sicculus** Cope.
One specimen taken.

17. **Lepomis megalotis** (Rafinesque).
Very abundant.

18. **Micropterus dolomieu** Lacépède.
Two specimens taken.

19. **Etheostoma copelandi** (Jordan).
Scarce; three specimens taken. Dorsal XI or XII—10; scales 48 to 52.

20. **Etheostoma flabellare** (Rafinesque).
Two specimens taken.

21. **Etheostoma cœruleum spectabile** (Agassiz).
Very abundant.

22. **Cottus bairdi** Girard.
Common.

V.—SPADRA CREEK.

In July, 1888, the writer made a small collection of fishes in Spadra Creek, a small tributary of the Arkansas River, from the north, near Clarksville, Ark. Spadra Creek is not large, has a rocky and gravelly bottom, except near its mouth. It contains clear water, which flows with considerable current. The following are the species obtained:

1. **Ictalurus punctatus** (Rafinesque).
Few specimens taken.

2. **Ictiobus velifer** (Rafinesque).
One specimen taken.

3. **Moxostoma duquesnei** (Le Sueur).
Common.

4. **Erimyzon sucetta** (Lacépède).
One specimen.

5. **Campostoma anomalum** (Rafinesque).
Common.

6. **Pimephales notatus** (Rafinesque).
Common. These specimens are like those found in the streams in Missouri.

7. **Notropis boops** (Gilbert).
Two small specimens taken.

8. **Notropis whipplei** (Girard).
Scarce.

9. **Notropis megalops** (Rafinesque).
Not common.

10. **Notemigonus chrysoleucus** (Mitchill).
One specimen.

11. **Zygonectes notatus** (Rafinesque).
Common.

12. **Dorosoma cepedianum** (Le Sueur).
One specimen.

13. **Labidesthes sicculus** (Cope).
One specimen.

14. **Lepomis megalotis** (Rafinesque).
Common.

15. **Lepomis humilis** (Girard).
Common.

17. **Etheostoma caprodes** Rafinesque.
One specimen.

18. **Etheostoma blennioides** Rafinesque.
One specimen.

19. **Aplodinotus grunniens** (Rafinesque).
One specimen.

C.—BASIN OF WHITE RIVER.

VI.—THE WHITE RIVER IN MISSOURI.

That portion of northern Arkansas and southern Missouri, which is drained by the White River and its tributaries, is considerably broken and mountainous, although none of its hills are of great height. The streams are fed by many springs, and except in rainy seasons their waters are very clear. Their bottoms are for the most part rocky and gravelly.

The *James River*, near Springfield, where visited, flows through a prairie region, although there is considerable timber along the borders of the stream. The river at this place is a beautiful stream of clear water, flowing over a rocky and gravelly bottom, except in a few places, where the water was deep and the current sluggish. The stream is from 40 to 75 feet wide. At the time of our visit its temperature was 76° Fah. The water was then quite low.

Bryant's Creek heads not far from Mansfield, Mo. It is fed by springs and its waters are very cold. The country south of Mansfield is heavily timbered and much broken, and the stream flows with a very swift current over a rocky bottom. The species of fishes in Bryant's Creek were not many, but rich in individuals. *Chrosomus erythrogaster* was by far the most abundant species. The temperature was 58° Fah.

The North Fork of the White, south of Cabool, flows through the most broken region in southern Missouri visited by us. The country is also heavily timbered and as yet sparsely settled. The stream has a rocky bottom and flows with a considerable current. One bank or the other is usually bordered by cliffs. *Hybopsis amblops*, taken

only in small numbers elsewhere, was here found to be by far the most abundant minnow. The temperature was 74° Fah.

1. **Noturus exilis** Nelson.
   One specimen from the James.

2. **Catostomus nigricans** Le Sueur.
   James and North Fork of the White, not common.

3. **Erimyzon sucetta** (Lacépède).
   North Fork of the White, common.

4. **Moxostoma duquesnei** (Le Sueur).
   James, common; North Fork of the White, one specimen.

5. **Campostoma anomalum** (Rafinesque).
   James, common; North Fork of the White and Bryant's Creek, abundant.

6. **Chrosomus erythrogaster** Rafinesque.
   Bryant's Creek, abundant. The specimens have yellow on the sides instead of red.

7. **Hybognathus nubila** (Forbes).
   James River and North Fork of the White, abundant; Bryant's, scarce. Females gravid.

8. **Pimephales notatus** (Rafinesque).
   James River and North Fork of the White, common.

9. **Notropis ozarcanus**, sp. nov.

Ten specimens from the North Fork of the White. Longest specimen 2¼ inches in length. Allied to *Notropis spectrunculus.* Body very slender, not much compressed, back very slightly arched. Mouth slightly oblique, small, end of maxillary scarcely reaching front of orbit. Eye large, its diameter 3 in the length of the head; preorbital bone large, slightly longer than deep. Head 4½ in the length of the body, depth 6½. Dorsal rays 7. Anal rays 8. Thirty-six scales in the lateral line. First dorsal ray midway between tip of snout and base of caudal fin. Pectoral fins short, their tips reaching three-fifths the distance to base of ventrals. Teeth 4 — 4, their tips hooked, grinding surface narrow, and with its edges slightly crenate. Color olivaceous, the sides punctulated with dark dots, forming a faint lateral band. Lips very thin; intestinal canal not longer than the body.

This species resembles *Notropis spectrunculus*, from which it differs in being more slender, in having a smaller and narrower head, a less blunt snout, and a narrower interorbital space.

10. **Notropis lutrensis** (Baird & Girard).
    James River, scarce.

11. **Notropis galacturus** (Cope).
    James River, scarce.

12. **Notropis zonatus** (Agassiz).
    James, Bryant's Creek, and North Fork, common.

13. **Notropis megalops** (Rafinesque).
    Found with the above, common.

14. **Notropis rubrifrons** (Cope).
    James River and Bryant's Creek, common.

15. **Notropis micropteryx** (Cope).
    James River, scarce.

16. **Hybopsis kentuckiensis** (Rafinesque).
James, common; North Fork of White, scarce.

17. **Hybopsis amblops** (Rafinesque).
James, common; North Fork of the White, by far the most abundant minnow.

18. **Semotilus atromaculatus** (Mitchill).
Bryant's Creek, one specimen.

19. **Fundulus catenatus** (Storer).
James, common. In some specimens the stripes on the sides are somewhat broken The caudal fin of one specimen is covered with black, in the others bordered with a dusky shade. Sides of head occasionally with orange spots.

20. **Zygonectes notatus** (Rafinesque).
James and North Fork of the White, scarce.

21. **Lucius vermiculatus** (Le Sueur).
North Fork of the White, common. Mr. Bartholomew, of Cabool, Mo., informed me that many large pickerel had been taken from this stream with the aid of dynamite. Probably these larger specimens are *Lucius reticulatus.*

22. **Ambloplites rupestris** (Rafinesque).
North Fork of the White River, James River, scarce.

23. **Lepomis cyanellus** (Rafinesque).
North Fork of the White River, scarce.

24. **Lepomis megalotis** (Rafinesque).
James and North Fork of the White, abundant.

25. **Micropterus dolomieu** Lacépède.
James and North Fork of the White, not common.

26. **Etheostoma blennioides** Rafinesque.
James and North Fork of the White, scarce.

27. **Etheostoma caprodes** Rafinesque.
James, scarce.

28. **Etheostoma juliæ**, sp. nov. (Plate XLII, fig. 2).
James River, three specimens.

Length of longest specimen 2¼ inches. Head 4 in the length of the body, depth 4 to 4⅙. Dorsal XI—11 or 12. Anal I, 7. Scales 8—58 to 60—8. Lateral line incomplete. Cheek and breast naked, opercles with few scales on upper part. Abdominal region scaled. Eye small, 4½ in the length of the head. Branchiostegal membranes broadly united, with 6 rays. Teeth on vomer. Body deep, compressed, with the dorsal region elevated, the form being much as in *Etheostoma uranidea.* Mouth terminal, the lower jaw the shorter; snout pointed, upper lip thick; maxillary slightly protractile. Tip of maxillary reaching to front of pupil. Pectoral fins large, their length equal to the length of the head; ventrals small.

Color in life dusky olivaceous, greenish below. Caudal fin, soft dorsal, anal and ventral fins yellowish; pectoral fins dusky, with outer border pale yellowish. Spinous dorsal dusky, upper half with a yellowish tinge; a faint dark band on chin; a dark bar below eye; a black band across back in front of spinous dorsal, terminating at base of pectoral fins; a second and much fainter band on back between spinous and soft dorsal; a third faint band on back at middle of soft dorsal, and a fourth on caudal peduncle. Sides dotted with faint yellowish, this forming irregular stripes along rows of scales. On the posterior half of body are six faint dark vertical bars.

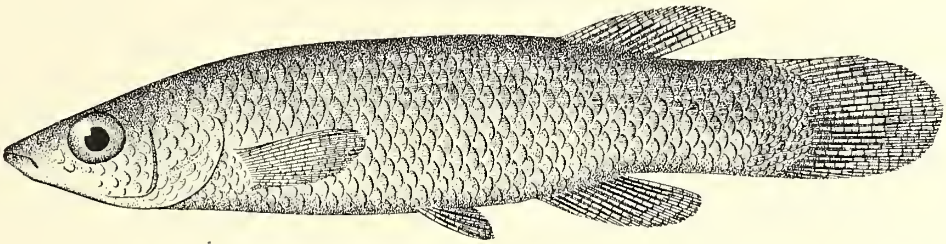


FIG. 1. ZYGONECTES MACDONALDI. (About twice natural size.)

(See page 122.)

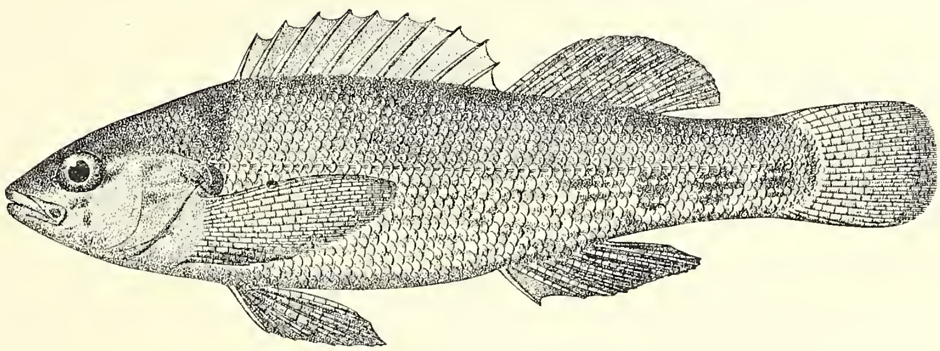


FIG. 2. ETHEOSTOMA JULIÆ. (Example 2¼ inches long.)

(See page 130.)

This is one of the handsomest of the darters. I take pleasure in naming it for Julia Hughes Gilbert. (Mrs. Charles H. Gilbert.)

29. **Etheostoma zonale** (Cope).

James, not common. Scale 56 to 58.

30. **Etheostoma nigrum** (Rafinesque).

North Fork of White River; not common.

31. **Etheostoma cœruleum** (Storer).

James, not common. Scales 44–46. Bryant's Creek, not common. Scale 37–40.

Var. *spectabile* (Agassiz).

James, not common. Scales 44. Bryant's Creek, common. Dorsal IX or X—12 to 14. Scales 37 to 40, cheek naked, opercles with few scales. Color in some female specimens much as in *E. cœruleum*, but darker, mottled, and with the bars very indistinct. The stripes on the sides are less distinct, and the bars have a tendency to form quadrate spots on the sides.

32. **Etheostoma whipplei** (Girard).

North Fork of White River, scarce.

33. **Cottus bairdi** Girard.

James and Bryant's Creek, common.

VII.—MAMMOTH SPRING.

Spring River, a tributary of the Black which empties into the White, has its rise in *Mammoth Spring*, in North Eastern Arkansas. About one-third of a mile below the spring, Spring River receives a tributary known as the *Warm Fork*.

From 3½ to 6½ miles west of Mammoth Spring are *English* and *Myatt Creeks*. These creeks unite and empty into Spring River at some distance below Mammoth Spring. We collected in all of these streams, and also in a small creek flowing through the town of Mammoth Spring and emptying into Spring River opposite the mouth of Warm Fork.

Mammoth Spring is one of the largest springs in the United States. Its volume of water remains quite constant during the entire year, never diminishing more than one-sixth in its amount. We reached the town of Mammoth Spring on Saturday night. It began raining late Saturday evening and continued to rain most of the following day. On Sunday and Monday the water from the spring was very clear, on Tuesday and Wednesday quite opaque, and by Thursday evening it was noticeably much clearer again. We were told by several persons that it was unusual for the water in the spring to become clouded. A dam has been constructed a short distance below the spring. The distance between the wheel pits on either side of the dam is 107 feet. Between the wheel pits the water at the time of our visit was flowing over the dam at the depth of 1 foot. A large amount of the water was also used to supply the fish hatchery. The water in the spring flows from a large fissure at the foot of a low cliff. By the construction of the dam a small lake of about 17 acres is formed. The water in the lake at one point near the foot of the cliff is 170 feet deep.

The *Warm Fork* when first seen by us was somewhat muddy and swollen. Its current is quite swift, and by four days the water was low enough to permit collecting with fair success. The bottom of Warm Fork, except near its mouth, was rocky and gravelly. Its temperature above the spring was 75° Fah. Its volume of water was

much less than that flowing from the spring. Below the mouth of Warm Fork, Spring River flows with a very swift current over a very rocky bottom.

When the Kansas City and Memphis Railroad was built, a few years ago, to avoid the erection of a couple of bridges the Spring River was changed from its original bed for a short distance below Mammoth Spring. The portion of the river cut off forms a large bayou. The bottom of the bayou is very muddy and contains a large amount of grass and pond weeds.

We seined in this bayou, in Warm Fork near its mouth, in Spring River just below the dam, in a small branch which empties into the bayou, and in Spring Branch near its mouth. With the exception of those fishes taken from the Spring Branch, all were put together in one collection, and they are recorded in the following list as from Spring River.

Within the past year and one-half a "Fish Farm" has been established at Mammoth Spring. This place, from the nature of the soil, and from the abundant supply of cold water, is favorable for the hatching and rearing of fishes. Those interested in the first attempt to rear trout are pleased at the results of the experiment. The temperature of the water in Mammoth Spring was 59° Fah. The water in the bayou was much warmer, and evidently contains many large pickerel and black bass. Many young of these fishes were caught, and many large ones jumped over our nets. At my request Mr. A. Mizell, manager of the Fish Farm, furnished me with the following data, which I extract from a letter written at Mammoth Spring, Ark., March 7, 1890.

The spring is 170 feet deep, 190 feet in diameter, and flows fifty thousand cubic feet per minute, temperature from 59° to 62° the year round, and does not vary in depth perhaps two inches at any season, so that the flow of water is almost uniform.

The spring is seldom milky or muddy. This Fish Farm Company began the process of hatching trout February, 1889. At that time 200,000 brook-trout eggs, 7,000 English, and 25,000 California Rainbow trout eggs were placed in the hatchery, which has a capacity of at least 1,000,000 eggs. Of those put in, 85 per cent. were hatched, and up to thirty days old the "young fry" did well, after which, from the carelessness of those employed, the water beetle was permitted to get in among the young fish in almost endless numbers, yes, millions, which killed from 75,000 to 100,000 of the young in less than thirty days. The corroding of the copper-wire gauze in the nursery boxes caused some loss, as did the placing of a number of the fish when four months old in outside ponds, supplied with water not properly aerated, from a subterranean flume. On this account, at nine months old, there were only 25,000 brook, 2,000 English, and 10,000 California Rainbow trout. But in size and weight these have surpassed anything perhaps on record; at nine months old weighing from 8 to 10½ ounces, and at twelve months from 11 to 12 ounces, and numbers of them examined had a large quantity of spawn. One eleven inches long had 1,470 eggs. These fish have been too much crowded to attain their most rapid growth; doubtless would not but for the superiority of the water to trout growth. This rapid development is doubtless due to the water which runs through the thirteen small pools in which they are. It abounds with varieties of moss, and water cress, besides snails by the million. The materials of which the levees are constructed is limestone soil, clay, small stone, and gravel. This farm is yet in its infancy, and by greatly enlarging its area, and by profiting from the mistakes and neglects of one year past, it is believed that the results it will yield will be remunerative almost beyond a parallel.

Myatt Creek was reached at a point 6½ miles southwest of Mammoth Spring. It is a clear, swift stream, broken in many places into several channels. Where these channels are united, the stream is from three to four feet deep and about fifty feet wide. Some of the branches were converted into bayous, mud-bottomed and snag-strewn. In these quiet arms, sunfish and catfishes were quite common. The bottom of the main stream was either rocky or covered with small, angular fragments of

flinty conglomerate. The stream, at the time of our visit, was considerably swollen by recent rains, and was somewhat muddy. The temperature was 75° Fah.

English Creek was similar in its physical characteristics to Myatt Creek. It is smaller, the current more sluggish, the bottom quite muddy. It contains large patches of *Sagittaria* and *Myriophyllum*. This stream was also swollen by the rains. Temperature 71° Fah.

1. **Ameiurus melas** (Rafinesque).
Myatt Creek, common.

2. **Ameiurus nebulosus** Le Sueur.
Bayou of Spring River, common; English Creek, scarce.

3. **Catostomus teres** (Mitchill).
Spring River, common.

4. **Catostomus nigricans** Le Sueur.
Spring River, Myatt and English Creeks; common.

5. **Erimyzon sucetta** (Lacépède).
Spring River, Myatt, scarce.

6. **Moxostoma duquesnei** (Le Sueur).
Spring River, Myatt, English Creek, common.

7. **Campostoma anomalum** (Rafinesque).
Spring River and Myatt Creek, common.

8. **Chrosomus erythrogaster** Rafinesque.
Spring Branch, common.

9. **Hybognathus nubila** (Forbes).
Spring River, Myatt and English Creeks, common.

10. **Pimephales notatus** (Rafinesque).
Warm Fork, not common; Myatt Creek, scarce.

11. **Notropis lutrensis** Baird and Girard.
Warm Fork, scarce.

12. **Notropis galacturus** (Cope).
Spring River, Myatt and English Creeks, scarce.

13. **Notropis zonatus** (Agassiz).
Spring River, Myatt and English Creeks, common.

14. **Notropis megalops** (Rafinesque).
Spring River, Myatt and English Creeks, abundant.

15. **Notropis umbratilis** (Girard).
Spring River, scarce.

16. **Notropis telescopus arcansanus** var. nov.

Longest specimen $2\frac{1}{4}$ inches in length. Head $4\frac{1}{4}$ to $4\frac{1}{2}$ in the length of the body. Depth 5 to $5\frac{1}{3}$. Scales 5—35 to 38—3. Fourteen to 15 scales in a series between nape and dorsal fin. Anal rays 10 or 11. Eye very large, $2\frac{3}{4}$ in the length of the head. Snout pointed, its length $3\frac{2}{3}$ in the length of the head. First ray of dorsal fin midway between base of caudal and nostril, ventrals slightly in advance of the dorsal. Body long and slender. Sides with an indistinct plumbeous band overlaid by silvery. Color dusky olivaceous above, silvery below. I have compared specimens from Mammoth Spring region with *Notropis telescopus* from Big Creek, Tennessee, Watauga River, Tennessee, and from Middle Fork of the Holstein River, Glade Spring, Virginia.

The color of the western form is darker, and the position of the dorsal fin is farther back than in the eastern forms examined. The eastern form apparently reaches a larger size.

Specimens of this species were taken by Jordan & Gilbert in the White River and its branches about Eureka Springs, Arkansas, in 1884, and in their list it was included with *Notropis boops* under the name of *Notropis scabriceps*. The true *scabriceps* is not found in Arkansas and *N. boops* is a distinct species.

17. **Notropis rubrifrons** (Cope).

Warm Fork, common; English Creek, scarce.

18. **Hybopsis kentuckiensis** (Rafinesque).

Spring River, Myatt and English Creeks, common.

19. **Hybopsis amblops** (Rafinesque).

One specimen from English Creek.

20. **Semotilus atromaculatus** (Mitchill).

Myatt Creek, Spring Branch, scarce.

21. **Salmo irideus** Gibbons. Rainbow Trout.

One specimen taken in Spring River, below the dam, escaped, no doubt, from the hatchery.

22. **Fundulus catenatus** (Storer).

Myatt Creek, abundant.

23. **Zygonectes notatus** (Rafinesque).

Spring River, Myatt and English Creeks, very common.

24. **Lucius vermiculatus** (Le Sueur).

Myatt, one specimen. Very abundant in a bayou of Spring River about three miles below Mammoth Spring.

25. **Lucius reticulatus** (Le Sueur).

English Creek, one specimen. Branchiostegal rays 14 and 15.

Bayou near Spring River, one specimen, 24 inches in length. Length of the head $7\frac{1}{4}$ inches. From tip of snout to the eye 4 inches. Dorsal rays 14, anal rays 14, only long rays counted. Branchiostegals 15. Scales in the lateral line 110. Cheeks and opercles scaly. Sides reticulated, the reticulations forming rather indistinct and irregular lateral stripes. This large specimen differed in color from several smaller specimens taken at same time and in same place. The large specimen was taken in a trammel net which was stretched across the bayou near its mouth. The sportsmen owning the net informed us that it was not uncommon to take pickerel of this size from the bayou.

The specimen from English Creek was compared with the Eastern and Southern specimens of *L. reticulatus*, from which it presented no appreciably specific or varietal differences. I have also examined a specimen of this species from Spring Valley, Shannon County, Mo., taken by Prof. R. E. Call in 1888. In a paper published by Professor Call on "A Collection of Fishes from the Ozark Region," in the Proceedings of the Davenport Academy of Sciences in 1887, the following notes are made under the species *Esox vermiculatus*: "Sinking Creek, Spring Valley Creek, and Jack's Fork, Shannon County. This species, which is locally called mountain trout, and occasionally pike, is abundant in all the larger streams in the mountains of Missouri." I have also been told by Professor Call that some of the specimens taken were from 18 inches to 2 feet in length.

It is quite certain that the geographical range of this species is much wider than has been supposed. It has been taken in the streams east and south of the Alleghanies, from Maine to Alabama, and west to Ithaca, N. Y. We now record it for the first time from the Ozark Mountain region, where it is apparently quite common. It is difficult to capture the pickerel in the small meshed seines used by us in collecting, as it is a swift swimmer and either runs around our nets or jumps over them.

This species is easily distinguished from the preceding by its longer snout and the large number of branchiostegal rays. Of the five species of this genus this one is most fond of the cool, clear mountain streams.

26. **Labidesthes sicculus** Cope.

Myatt Creek; scarce.

27. **Ambloplites rupestris** (Rafinesque).

Spring River and English Creek, not common.

28. **Chænobryttus gulosus** (Cuvier and Valenciennes).

Myatt Creek, two specimens taken.

29. **Lepomis cyanellus** (Rafinesque).

Spring River and English Creek, scarce; Myatt Creek, between Myatt and Mammoth Spring, common.

30. **Lepomis garmani** Forbes.

Length of longest specimen $5\frac{1}{2}$ inches. Head $2\frac{4}{5}$ to 3 in the length of body. Depth $1\frac{3}{4}$ to 2. Scales 8—35 to 38—10. Pharyngeal teeth not paved; teeth on vomer, none on the palatines; 5 rows of scales on the cheeks. Opercular flap small, without pale edge. Body deep, compressed, more robust than in *Lepomis megalotis*. Mouth small, very oblique, no distinct supplemental maxillary bone. Profile rather steep with an angle above eye. Lower jaw the longer, the chin very prominent.

Color dark greenish above, sides tinged with red above lateral line, while on the lower part of the body red becomes the predominating color; breast tinged with yellow. The red on sides appears as a nearly square blotch on each scale. No blue stripes on head. Young covered with bronze spots. This species was found very abundant in Spring River.

31. **Lepomis pallidus** (Mitchill).

Spring River, common; English and Myatt Creek, scarce.

32. **Lepomis megalotis** Rafinesque.

Spring River and English Creek, common; Myatt, abundant.

33. **Micropterus salmoides** (Lacépède).

Spring River, English, and Myatt Creeks; common.

34. **Micropterus dolomieu** Lacépède.

Spring River, scarce.

35. **Etheostoma blennioides** Rafinesque.

Spring River, English, and Myatt Creeks; scarce.

36. **Etheostoma zonale** (Cope).

Spring River, one specimen.

37. **Etheostoma cœruleum** Storer.

Spring River, a few specimens.

Var. *spectabile* (Agassiz).

These specimens resemble those from Bryant's Creek, except that they are less brightly colored. Scales in the lateral line 40 to 46. Dorsal fin IX to XI—12 to 13.

Opercles on a few specimens nearly scaleless. Spring River, Spring Branch, Myatt, and English Creeks; common.

38. **Cottus bairdi** Girard.

Spring River, abundant near the dam. Called "Cod" by the inhabitants of Mammoth Springs. The specimens of this species vary much in color; some are nearly black, while others are almost brick red; some are much mottled while others have the dark vertical bands prominent. Some specimens taken were more than 6 inches in length.

VIII.—LITTLE RED RIVER.

The *Little Red River* at Judsonia, Ark., reaches a considerable size, and at the time of our visit was much swollen by floods. The current is sluggish and the banks rather steep and muddy. The temperature was 79° Fah. The river was too high to admit of seining, and so the collecting was done in a small tributary near Judsonia. This stream has a sluggish current and muddy bottom. The Little Red River is a southern tributary of the White River.

1. **Erimyzon sucetta** Lacépède.

Not common; 44 scales in the lateral line.

2. **Hybognathus nuchalis** (Agassiz).

Common.

3. **Notropis whipplei** (Girard).

Scarce.

4. **Notropis megalops** (Rafinesque).

One specimen.

5. **Notropis umbratilis** (Girard).

Common.

6. **Notropis atherinoides caddonis** (new variety).

Length of longest specimen 3 inches. Head $4\frac{1}{3}$ to $4\frac{1}{2}$ in the length of the body. Depth $5\frac{1}{2}$. Scales 36 to 39 in the lateral line. Anal rays 11. Dorsal rays 8. Eye 3 in the head. Snout $3\frac{3}{4}$ in the head. Origin of first dorsal ray midway between the pupil and base of caudal fin. Eighteen or 19 scales before dorsal fin. Body slender. Eye large. Snout short. Color light olivaceous, with a faint plumbeous lateral band, overlaid by silvery lateral line decurved. This form differs from the ordinary *atherinoides* in having a comparatively larger eye and a shorter snout. It was found also in the Caddo River.

7. **Semotilus atromaculatus** (Mitchill).

Scarce.

8. **Zygonectes notatus** (Rafinesque).

Not common.

9. **Lucius reticulatus** (Le Sueur).

One specimen.

10. **Labidesthes sicculus** (Cope).

Not common.

11. **Aphredoderus sayanus** (Gilliams).

One specimen. Fifty scales in the lateral line.

12. **Elassoma zonatum** Jordan.

One small specimen. The species was originally described from Judsonia.

13. **Chænobryttus gulosus** (Cuv. & Val.).
One specimen.

14. **Lepomis cyanellus** Rafinesque.
One specimen.

15. **Etheostoma blennioides** Rafinesque.
One specimen.

16. **Etheostoma zonale** (Cope).
One small specimen.

17. **Etheostoma microperca** Jordan & Gilbert.
Two specimens. D. VIII–10. A. II–6. Scales 36.

18. **Etheostoma fusiforme** (Girard).
Scarce.

D.—BASIN OF THE WASHITA.

IX.—WASHITA RIVER.

The *Ouachita* or *Washita River* is one of the largest streams in southwestern Arkansas. It rises in the southern range of the Ozark Mountains, and empties into the Mississippi River. The head waters of the Ouachita and of its tributaries are swift-flowing streams of clear water. Their bottoms are rocky and gravelly.

The Ouachita was visited near Crystal Springs, Ark. Most of the seining was done at the ford. Above and below the ford the water was too deep for our nets. In the deep places large rocks were numerous, and the bottoms less gravelly than in the shallower water. The current of the Ouachita was less swift than in any of its tributaries.

The tributaries of the Ouachita examined are all much alike in physical characteristics. The Caddo River was the largest visited. The South Fork of the Ouachita next in size, Mazarn and Myers Creeks being rather small.

The *Caddo River* was seined at Caddo Gap and near Black Springs, and also in two small tributaries between these points. The Caddo is a beautiful stream, but evidently contains few fishes and few species. Near Black Spring the Caddo divides itself into several small streams. This affords excellent opportunities for collecting, but fishes were found in fewer numbers than in any other stream in which we collected during the summer. Temperature, 76° Fah.

The *South Fork of the Ouachita* was seined near Mount Ida. This stream afforded as favorable opportunities as did the Caddo, especially in the long deep holes. The strata of rock are nearly vertical, and lying across the stream, form by unequal wear a series of ridges and furrows in the shallower places. The stream varies in width from 40 to 70 feet, and the water is from 1 to 5 feet or more in depth. In the deeper holes were much pond weeds and grass, which made hiding places for black bass (*M. dolomieu*, *M. salmoides*) and pickerel (*Lucius vermiculatus*), which seemed rather common. More fishes were found in this stream than in the Caddo. The temperature was 74° Fah.

The *Mazarn* is a tributary of the Ouachita, and *Myers' Creek* flows into the Mazarn. These streams were examined near Myers. Neither is large, and neither contained many fishes.

The *West and Middle Forks of the Saline* are both about 24 miles east of Hot Springs.

These streams are not large, and their bottoms are too rocky to admit of very successful seining. The scarcity of fishes in these streams was very noticeable. The temperature of the Middle Fork was 76° Fah.; of the South Fork, 74° Fah. Dr. John C. Branner, geologist of Arkansas, informed the writer that large numbers of fishes were found dead along the Saline Forks the preceding summer. It is thought that they had been killed by dynamite.

1. **Noturus nocturnus** Jordan & Gilbert.
   Ouachita and the Saline; only a few small specimens taken.

2. **Erimyzon sucetta** (Lacépède).
   Caddo and Mazarn; scales in lateral line, 44.

3. **Catostomus nigricans** Le Sueur.
   Common in all streams.

4. **Moxostoma duquesnei** (Le Sueur).
   Common in all streams.

5. **Campostoma anomalum** (Rafinesque).
   Not common; taken in all streams.

6. **Chrosomus erythrogaster** (Rafinesque).
   One specimen from the South Fork of the Ouachita.

7. **Hybognathus nubila** Forbes.
   West and Middle Forks, Saline River, Hot Springs, Ark.

8. **Pimephales notatus** (Rafinesque).
   The specimens of this species from the Ouachita Basin seem quite different from specimens taken elsewhere. The body is more slender and the top of the head is flatter. Head, $4\frac{3}{4}$ in the length of the body; depth, 5; scales in the lateral line, 44 to 46; sides with a distinct lateral band, more prominent on snout. Common in all streams.

9. **Notropis boops** Gilbert.
   The most abundant minnow in all streams, especially in the colder ones like the Caddo.

10. **Notropis whipplei** (Girard).
   Abundant in all streams.

11. **Notropis megalops** (Rafinesque).
   Not common; Caddo, Mazarn, and the Saline.

12. **Notropis umbratilis** (Girard).
   Not common; taken in all streams.

13. **Notropis atherinoides caddonis** Meek.
   One specimen from the Caddo; Ouachita, Mazarn, and Myers' Creeks; scarce; head, $4\frac{1}{2}$; depth, 6; scales in lateral line, 39; 17 scales before dorsal fin; eye, $3\frac{1}{4}$ in head; snout, $3\frac{1}{2}$; dorsal inserted midway between pupil and base of caudal. Length of longest specimen, $2\frac{1}{2}$ inches.

14. **Hybopsis dissimilis** (Kirtland).
   Two specimens from the Ouachita.

15. **Semotilus atromaculatus** (Mitchill).
   Two specimens from the Caddo.

16. **Fundulus catenatus** (Storer).
   Taken in all streams; common.

17. **Zygonectes notatus** (Rafinesque).
South Fork Ouachita, Mazarn, Saline, and Caddo Rivers.

18. **Lucius vermiculatus** (Le Sueur).
One specimen from Mazarn and one from South Fork of the Ouachita.

19. **Labidesthes sicculus** Cope.
All streams; very common.

20. **Aphredoderus sayanus** (Gilliams).
One specimen from the Caddo; scales 53.

21. **Ambloplites rupestris** (Rafinesque).
Ouachita and South Fork of the Ouachita; common.

22. **Chænobryttus gulosus** (Cuv. and Val.).
Caddo River, Caddo Gap, Ark., scarce.

23. **Lepomis cyanellus** (Rafinesque).
All streams except the Saline; not common.

24. **Lepomis pallidus** (Mitchill).
Caddo Creek; scarce.

25. **Lepomis megalotis** Rafinesque.
All streams; common.

26. **Micropterus salmoides** (Lacépède).
One specimen from the Ouachita, two from the Caddo.

27. **Micropterus dolomieu** Lacépède.
All streams; rather common.

28. **Etheostoma nigrum** Rafinesque.
One specimen from the Caddo.

29. **Etheostoma blennioides** Rafinesque.
Very abundant in the Ouachita; common in the other streams.

30. **Etheostoma copelandi** (Jordan).
Seven specimens from the Ouachita.

31. **Etheostoma caprodes** Rafinesque.
Three specimens from the Ouachita.

32. **Etheostoma phoxocephalum** Nelson.
Abundant in the Ouachita.

33. **Etheostoma zonale** (Cope).
Ouachita, abundant; South Fork of the Ouachita, Caddo, and Saline, scarce.

34. **Etheostoma whipplei** (Girard).
Common. Taken in all streams. Scales in the lateral line 50 to 60. Dorsal spines 9 to 12.

35. **Etheostoma chlorosoma** (Hay).
(*Boleosoma camurum* Forbes.) A few specimens from the Ouachita.

36. **Etheostoma stigmæum** (Jordan).
(*Pœcilichthys saxatilis* Hay, *fide* Gilbert.) Ouachita and South Fork of the Ouachita, scarce; Caddo River, Caddo Gap, Ark.; scarce.

APPENDIX.

COLLECTIONS OF MR. CALL IN SOUTHERN MISSOURI.

In June and July, 1886, Mr. Richard Ellsworth Call, of Des Moines, Iowa, made a collection of fishes in Dent, Texas, Reynolds, and Shannon Counties, in Missouri A portion of this collection is in the Smithsonian Institution, Washington, D. C., a portion in the University of Indiana, and the rest in the University of Missouri.

A list of the species collected was published by Professor Call in the Proceedings of the Davenport Academy of Natural Sciences, 1887.

The following list is made up from this paper, and from an examination of a portion of the collection sent out by Mr. Call to the Museum of the Indiana University.

The collections were made in the Meramec River (M.); in tributaries of the Gasconade as follows: Piney (P.) and Big Creek (B.); and in tributaries of the Black River as follows: (W) West Fork, (J) Jack's Fork, (T.) Tom's Creek, (S) Sinking Creek, and in (Ba.) Barren Creek.

1. **Ictalurus punctatus** (Rafinesque). P.
2. **Catostomus teres** (Mitchill). J. T.
3. **Catostomus nigricans** Le Sueur. M. T.
4. **Moxostoma duquesnei** (Le Sueur). (*Moxostoma macrolepidotum* Call.) M; P. B.; W. J.
5. **Campostoma anomalum** (Rafinesque).

   Taken in all streams.
6. **Chrosomus erythrogaster** Rafinesque. W. T.; S. Sp. J.
7. **Hybognathus nubila** (Forbes). (*Dionda nubila* Call, and *Hybognathus meeki* Call.) W. T. J. P.
8. **Hybognathus nuchalis** Agassiz. M; P.
9. **Notropis boops** Gilbert. (*Notropis deliciosus* Call; *Notropis scabriceps* Call.) M. P.; Sp. W.
10. **Notropis whipplei** (Girard). (*Notropis notatus* Call.) P. W. T. J. Sp. S. Ba.
11. **Notropis galacturus** (Cope). J. Sp.
12. **Notropis megalops** (Rafinesque).

    Taken in all streams.
13. **Notropis zonatus** (Agassiz).

    Found with the preceding species.
14. **Notropis telescopus arcansanus** (Meek). (*Notropis micropteryx* Call.)

    I compared one specimen taken by Professor Call with those from Spring River, Mammoth Spring. All belong to the same species.
15. **Notropis umbratilis** (Girard). Sp.
16. **Semotilus atromaculatus** (Mitchill). M; B; W. T. B. Sp.
17. **Fundulus catenatus** (Storer).

    Taken in all streams.
18. **Zygonectes notatus** (Rafinesque). W. J.
19. **Lucius vermiculatus** (Le Sueur). S. Sp. J.
20. **Lucius reticulatus** (Le Sueur).

    One specimen in the Indiana University Museum, from Spring Valley creek.
21. **Ambloplites rupestris** (Rafinesque). W. Sp. J.

22. **Lepomis megalotis** (Rafinesque). J.

23. **Micropterus dolomieu** Lacépède.

Taken from all streams.

24. **Etheostoma nigrum** Rafinesque. (*Boleosoma olmstedi ozarcanum* Call.) B; J.

25. **Etheostoma blennioides** Rafinesque. J. S. W.

26. **Etheostoma punctulatum** (Agassiz). B.

27. **Etheostoma cœruleum spectabile** Agassiz. W. Ba. S. Sp. B.

28. **Cottus bairdi** Girard.

Abundant in all streams.

The following is a list of species taken by Professor Call from (B) Bear and (H) Hinkson Creeks, tributaries of the Missouri River near Columbia, Mo.:

1. **Noturus exilis** Nelson. B. H.
2. **Catostomus teres** (Mitchill). B. H.
3. **Moxostoma duquesnei** (Le Sueur). H.
4. **Campostoma anomalum** (Rafinesque). B. H.
5. **Pimephales promelas** Rafinesque. B.
6. **Pimephales notatus** (Rafinesque). B.
7. **Notropis deliciosus** (Girard). B.
8. **Phenacobius mirabilis scopifer** Cope. B.
9. **Semotilus atromaculatus** (Mitchill). B.
10. **Pomoxis annularis** Rafinesque. B.
11. **Lepomis cyanellus** Rafinesque. B. H.
12. **Lepomis humilis** (Girard). B.
13. **Etheostoma nigrum** Rafinesque. B.

Coe College, Cedar Rapids, Iowa, *March* 19, 1890.

10.—REPORT OF EXPLORATIONS MADE IN ALABAMA DURING 1889, WITH NOTES ON THE FISHES OF THE TENNESSEE, ALABAMA, AND ESCAMBIA RIVERS.

BY CHARLES H. GILBERT.

The present paper is based primarily on collections and observations made during the summer of 1889 for the U. S. Fish Commission, by Philip H. Kirsch, William M. Andrews, and Everett O. Jones, students in the Indiana University. I have also added notes on such additional species as were obtained from the same region by Prof. Joseph Swain and the writer in 1884, and by Jordan, Evermann, and Bollman in 1886.

With the exception of the larger river fishes, which have not been collected by us, the present list is probably approximately complete for the bend of the Tennessee River. The results of the examination have been mainly noteworthy as showing the presence in the clear, cold spring-fed tributaries of this lower portion of the river of an unexpectedly large number of species characteristic of the head waters of the French Broad and the Holston Rivers.

The list from the Alabama River is far from complete, and additional collections are much needed from that region.

The following streams were examined:

A.—The Tennessee River:
- 1. Pin-hook Creek, Huntsville, Ala.
- 2. Spring Branch, Huntsville, Ala.
- 3. Veta Wright Creek, Decatur, Ala.
- 4. Mallett Creek, Hillsborough, Ala.
- 5. Spring Creek, Courtland, Ala.
- 6. Big Nance Creek, Courtland, Ala.
- 7. Spring Creek and Branch, Tuscumbia, Ala.
- 8. Cypress Creek, Florence, Ala.
- [9. Shoal Creek, Florence, Ala.*]
- [10. Duck River, Columbia, Tenn.*]
- [11. Richland Creek, Pulaski, Tenn.*]
- [12. Pigeon Roost Creeks, Pulaski, Tenn.*]

B.—The Alabama River:
- I. The Black Warrior River:
  - [1. Eight-mile Creek, Cullman, Ala.*]
  - 2. Mulberry River, Blount Springs, Ala.
  - 3. Stone Creek, Blount Springs.
  - 4. Black Warrior at Warrior Station, and Morris, Ala.*

B.—Alabama River—Continued.
  - 5. Black Warrior, Tuscaloosa, Ala.
  - 6. North River, Tuscaloosa, Ala.*
- II. The Coosa River:
  - 1. Cahawba River, Helena, Ala.
  - 2. A small creek at Calera, Ala.
  - 3. Clear Creek, Attalla, Ala.
  - 4. Will's Creek, Attalla, Ala.
  - 5. Choccolo Creek, Oxford, Ala.
  - 6. Chestnut Creek, Verbena, Ala.

C.—The Escambia River:
- 1. Persimmon Creek, Greenville, Ala.
- 2. Hawkins Creek, Greenville, Ala.
- 3. Sand Creek, Evergreen, Ala.
- 4. Murder Creek, Evergreen, Ala.
- 5. Little Escambia River, Pollard, Ala.
- 6. Will's Creek, Pollard, Ala.
- 7. Black Creek, Pollard, Ala.
- [8. Escambia River at Flomaton, Ala.*]
- [9. Escambia River at its mouth.†]

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* Collections of Gilbert and Swain, 1884.

† Collections of Jordan, Evermann, and Bollman in 1886.

The following account of each of the streams examined is taken from the field notes of Mr. Kirsch:

THE TENNESSEE BASIN.

1. *Pin-hook Creek, Huntsville*, May 28, 1889. Temperature 74° Fah. Water clear, flowing swiftly; bottom of blue limestone. Stream about 40 feet wide on the ripples and literally full of fishes, but no darters were obtained.

2. *Spring Creek, Huntsville*, May 27. Temperature 65° Fah. This small stream about 18 feet wide is formed by a single spring in the town of Huntsville. It is about one-fourth of a mile long and flows into Pin-hook Creek. Its bottom is similar to that of the former. It is full of fishes, darters being very numerous.

3. *Veta Wright Creek, Decatur*, June 1. A small stream 3 miles south of the town, about 15 feet wide and 3 feet deep, rather sluggish, the ripples covered with loose rocks of limestone and flint. In the deep holes are sticky mud and occasional large rocks. There is much driftwood. This stream flows northward into the Tennessee. Crayfishes are abundant.

4. *Mallett Creek, Hillsborough*, June 8, temperature 70° Fah. This is a small stream about 12 feet wide, with deep holes and many ripples. The bottom is sandy and smooth. Sunfish, pike, and catfish abound; but few darters and minnows.

5. *Spring Creek, Courtland*, June 7. A cold stream rising in three or four springs. It has few ripples, a channel mostly deep and narrow, water swift. At some places it broadens into wide ponds. Examined at a point 3½ miles northeast of Courtland, Rock bass were especially abundant. Eighteen, taken from a single hole, averaged 2 pounds each.

6. *Big Nance Creek at Courtland*, June 7. A clear, cold, clean stream, about 4 feet wide. Bottom of limestone and flint with much loose rock. From the mill-pond at Courtland down the stream for about a mile there are many ripples. Below that, for 2 miles or more, the water is deep and flows slowly, and fish are very abundant.

7. *Spring Branch, Tuscumbia*, June 6. Temperature 52° Fah. This stream is formed by a single spring, is about one-eighth of a mile long, and flows into Spring Creek. The water is cold, clear, and swift. The bottom is strewn with rocks, and in many places overgrown with weeds. The stream contains little except darters and blob.

8. *Cypress Creek at Florence*, June 5. Temperature 68° Fah. A beautiful stream, about 75 feet wide, the water deep, the bottom a solid bed of flinty rock; but few ripples. The stream is full of small fish.

THE ALABAMA BASIN.

TRIBUTARIES OF THE BLACK WARRIOR RIVER.

1. *Mulberry River at Blount Springs*, May 25. This stream is about 100 yards wide at the ford 2 miles from the town. It flows over a solid bed of rock, covered with many loose stones. The rocks dip upstream and crop out in large shelves.

2. *Stone Creek, Blount Springs*, May 25. A tributary of Mulberry River, so filled with irregular large rocks that seining is almost impossible.

3. *Black Warrior River, at Tuscaloosa*, May 21. Temperature 70° Fah. Collections were made chiefly on the lower shoals under the bridge; bottom of rock, covered with shingle. A great variety of fishes were taken.

TRIBUTARIES OF COOSA RIVER.

1. *Cahawba River, at Helena*, May 20. Temperature 70° Fah. This stream is about 150 feet wide and rather deep, the bottom covered with large rocks and fragments of flint. There are many ripples and some deep holes. Fishes are abundant.

2. *Calera Creek, Calera*, May 18. Temperature 68° Fah. A small stream 20 or 25 feet wide, slow flowing and not deep; the deeper holes with muddy bottom and full of snags. The ripples are covered with sand and loose pebbles. This stream was examined at a point about a mile from town, to the southwest.

3. *Clear Creek, Attalla*, May 24. A small stream about 15 feet wide flowing through a very hilly country. The bottom in the holes is covered with mud, the ripples with coarse gravel and sand. This stream flows into Will's Creek. It abounds in small fish.

4. *Will's Creek, Attalla*, May 24. Temperature 68° Fah. This stream is from 80 to 100 feet wide, rather deep, clear and cool. But few ripples, and these covered with loose rocks and finer gravel and sand. The bottom is flinty at places. Few fishes were taken.

5. *Choccolo Creek, at Oxford*, May 23. Temperature 68° Fah. Examined at a point 2 miles south of the town. This stream is about 60 feet wide, rather deep, clear and cool, with many ripples. On the ripples the water is swift and very shallow, the bottom covered with limestone. Fish are plenty. Shad were placed in this stream some years ago, but are said to be rarely taken.

6. *Chestnut Creek, at Verbena*, May 7. Temperature 70° Fah. This stream is about 30 feet wide and not very deep. The bottom is very rocky, covered with loose bowlders. The ripples are full of loose rocks, pebbles, and sand. Large fish are scarce. Following this stream 2 miles, we found six fish traps.

THE ESCAMBIA RIVER BASIN.

1. *Persimmon Creek, Greenville, Ala.*, May 15. A small stream 3 miles southeast of Greenville, 10 or 15 feet wide, shallow and muddy.

2. *Hawkins Creek, Greenville*, May 15. Temperature 66° Fah. Rather a deep, muddy stream, about 30 feet wide and full of snags. Seined at a point 5 miles south of Greenville.

3. *Sand Creek, at Evergreen*, May 14. A small stream 10 or 12 feet wide, shallow bottom, mostly muddy, sometimes gravelly. Seined at a point 3 miles east of Evergreen.

4. *Murder Creek, at Evergreen*, May 14. Temperature 73° Fah. This stream was visited at a point $2\frac{1}{2}$ miles south of Evergreen. It flows for miles through low woodland, and is consequently full of snags and driftwood. There are many deep holes and few shoals. The shoals are covered with loose stones, the deeper parts full of mud.

5. *Little Escambia River, at Pollard*, May 13. Temperature 70° Fah. At about a mile south of Pollard the Little Escambia is about 50 feet wide, its water deep and

very swift. It flows through the woods, and is in places full of brush and driftwood. The ford is gravelly and sandy.

6. *Mill Creek, at Pollard*, May 13. Temperature 71° Fah. This is a small, dirty, sluggish little stream a mile north of town.

7. *Black Creek, at Pollard*, May 13. This is a small weedy stream 2 miles north of town. Its bottom is very muddy.

8. *Escambia River, at Flomaton, Ala.* Collections of Jordan, Evermann and Bollman, 1886. The stream at this point is clear and swift, the water rather cold, the bottom of sand and fine gravel.

9. *Escambia River, near its mouth in Florida.* Collections obtained from fishermen by Jordan and Bollman, 1886.

The following is in brief an itinerary of the summer's work in 1889:

May 6.—Left Bloomington, Ind., the party consisting of P. H. Kirsch, E. O. Jones, and Wm. M. Andrews.
May 8.—At New Orleans, seined near West End, on Lake Pontchartrain.
May 9.—At Biloxi, Miss., Biloxi Bay.
May 10.—At Ocean Springs, Miss.
May 11.—At Ocean Springs, Miss., seined at Fort Bayou.
May 13.—At Pollard, Ala.
May 14.—At Evergreen, Ala.
May 15.—At Greenville, Ala.
May 17.—At Verbena, Ala.
May 18.—At Calera, Ala.
May 20.—At Helena, Ala.
May 21.—At Tuscaloosa, Ala.
May 23.—At Oxford, Ala.
May 24.—At Attalla, Ala.
May 25.—At Blount Springs and Huntsville, Ala.
May 27, 28.—At Huntsville.
June 1.—At Decatur, Ala.
June 4.—At Tuscumbia, Ala.
June 5.—At Florence, Ala.
June 6.—At Tuscumbia, Ala.
June 7.—At Courtland, Ala.
June 8.—At Hillsboro, Ala.
June 9.—Returned to Bloomington.

A.—The Bend of the Tennessee River.

1. **Lepidosteus osseus** L.

Found abundant in a pond emptying into Richland Creek at Pulaski, Tenn. The species does not often enter the smaller streams.

2. **Noturus miurus** Jordan.

Not abundant. Specimens taken in Duck River and in Cypress Creek.

3. **Noturus exilis** Nelson.

Rare. A few specimens from Richland and Cypress Creek.

4. **Noturus flavus** Raf.

Taken only in Shoal Creek at Florence.

5. **Ameiurus melas** Raf.

From Spring Creek, Huntsville.

6. **Ameiurus natalis** Le Sueur.

Mallett's Creek and Veta Wright Creek.

7. **Ictalurus punctatus** Raf.

Abundant in the Tennessee at Florence. Small specimens taken in Spring Creek at Courtland.

8. **Carpiodes difformis** Cope.

Richland Creek.

9. **Ictiobus bubalus** Raf.

Tennessee River at Florence.

10. Catostomus teres Mitchill.

Generally abundant in small tributaries of the Tennessee River.

11. Catostomus nigricans Le Sueur.

Abundant.

12. Erimyzon sucetta Lac.

A pond-fish. Not often taken in small streams. Found only in Cypress and Veta Wright Creeks.

13. Minytrema melanops Raf.

Moderately abundant.

14. Moxostoma macrolepidotum duquesnei Le Sueur.

Generally abundant.

15. Moxostoma anisurum Raf.

Not abundant. Taken in Richland Creek, Pulaski, and Spring Creek, Courtland.

16. Lagochila lacera Jordan and Brayton.

This interesting species was found abundant in Richland and Cypress Creeks.

17. Campostoma anomalum Raf.

Generally abundant. This species swarms in the clear cold streams entering the Tennessee, and is usually more slender and darker colored than when found farther north. I am not, however, able to recognize the species (or subspecies) *prolixum*, as the two forms perfectly intergrade.

18. Chrosomus erythrogaster oreas Cope.

Found only in Cypress Creek, where it is not abundant. The specimens were much brighter in coloration than is found in typical *erythrogaster*, and the lateral black band is interrupted instead of continuous as in the latter. The coloration is still brighter in typical *oreas* from the Roanoke River, but the pattern of coloration is the same, and *oreas* probably intergrades perfectly with *erythrogaster*.

19. Hybognathus nuchalis Agassiz.

Not generally abundant. Found at Tuscumbia, Courtland, and Huntsville.

20. Pimephales notatus Raf.

Everywhere abundant.

21. Cliola vigilax Baird & Girard.

At Tuscumbia, and in Richland Creek, Pulaski.

22. Notropis spectrunculus Cope.

This species, so abundant in mountain streams tributary to the Holston and French Broad Rivers, is very rare along the Lower Tennessee. Two specimens only have been taken, in the Big Nance Creek at Courtland.

23. Notropis deliciosus Girard.

A single specimen from the Big Nance.

24. Notropis whipplei Girard.

Generally abundant.

25. Notropis galacturus Cope.

Widely distributed, but less abundant than in mountain streams.

26. Notropis megalops Raf.

Everywhere the most abundant species.

27. Notropis coccogenis Cope.

Rare along the lower course of the Tennessee. A single specimen from Cypress Creek.

28. **Notropis ariommus** Cope.

Very abundant in Cypress Creek, but not taken elsewhere.

29. **Notropis boops** Gilbert.

Very abundant in Cypress Creek; taken also in the Big Nance and Veta Wright Creeks.

30. **Notropis leuciodus** Cope.

Like *spectrunculus*, *galacturus*, and *coccogenis*, this is a species characteristic of the mountain streams, and infrequently taken along the Lower Tennessee. Specimens were obtained in Cypress and Big Nance Creeks.

31. **Notropis umbratilis fasciolaris**, subsp. nov.

Everywhere abundant.

A comparison of these specimens with others from the Roanoke River (*ardens*), the Pamlico and Neuse (*matutinus*), the Wabash in Indiana (*cyanocephalus*), various streams in Illinois (*atripes*), and the Arkansas River (*umbratilis*), has shown the impossibility of recognizing any of these forms as distinct species. *Matutinus* is smaller and paler than *ardens*, and shows less brilliant coloration, these differences being apparently dependent upon the sluggish character of the streams which it inhabits, with their frequent sandy stretches. The resemblance between specimens from the Roanoke and the Tennessee is very close. Both have larger mouth and eye, more brilliant coloration, and more elongate form than in specimens from the north and west. Our specimens from the Tennessee, however, average distinctly deeper than typical *ardens*, and are further characterized by the presence, in males, of several (5 to 8) dark steel-blue, vertical bars, irregular in position and shape. This form I here distinguish provisionally as subspecies *fasciolaris*. In Tennessee and Kentucky it undoubtedly passes insensibly into the form common in tributaries of the Ohio and Mississippi (*cyanocephalus*, *atripes*), which shows usually an evidently deeper body, a smaller eye, and a tendency to the accumulation of black pigment in the tips of the ventrals and the anterior rays of the dorsal and anal. Typical *umbratilis* from Kansas and Arkansas appears very distinct from the more easterly form. It has the larger eye of *fasciolaris*, a very deep body, and adult males have all the fins largely black and the sides uniform dusky. Furthermore, the black spot at the base of the anterior dorsal rays, so characteristic of related forms, is here indistinct or wanting. In Iowa and Missouri, however, *umbratilis* appears to pass imperceptibly into *cyanocephalus*, some specimens lacking the dorsal spot, while others from the same locality, and not otherwise differing, have it well developed.

I have thought it best, therefore, to consider all these forms as poorly defined varieties of a single widespread species, which may stand provisionally as *N. umbratilis umbratilis*, *N. umbratilis cyanocephalus*, *N. umbratilis fasciolaris*, *N. umbratilis ardens*, and *N. umbratilis matutinus*. East of the Alleghanies the species has not been recorded north of the Roanoke nor south of the Neuse, and is not known from the Gulf States south of the Tennessee and Arkansas basins.

Rafinesque's *Semotilus diplæmius*, so long identified with this species, is evidently *Semotilus atromaculatus*, as a synonym of which it must appear.

32. **Notropis micropteryx** Cope.

A few specimens taken in Shoal Creek, near Florence, Ala.

33. **Ericymba buccata** Cope.

Not abundant in Cypress Creek.

34. **Phenacobius uranops** Cope.

Very abundant in all small clear tributaries of this portion of the Tennessee. Specimens from Cypress Creek, Big Nance, Shoal Creek, Duck River at Columbia, and Richland Creek at Pulaski, Tenn.

35. **Rhinichthys atronasus** Mitchill.

Abundant in clear, cold streams fed by springs. Taken in Cypress Creek, Florence, and Pin Hook and Spring Creeks, Huntsville.

36. **Hybopsis kentuckiensis** Raf.

Cypress Creek, Mallett's Creek, and Duck River.

37. **Hybopsis dissimilis** Kirtland.

Rare. A few specimens from Shoal Creek.

38. **Hybopsis amblops** Raf.

Everywhere abundant.

39. **Hybopsis monachus** Cope.

Rare in Shoal Creek, Florence. Not seen elsewhere.

40. **Semotilus atromaculatus** Mitchill.

Generally abundant in ponds and sluggish streams. The lateral line averages about 55, as in specimens from the Alabama basin. I am not able to recognize the subspecies *thoreauianus*.

41. **Phoxinus vittatus** Cope (*Phoxinus flammeus* Jordan & Gilbert).

Found exceedingly abundant in the Huntsville Spring and in the small stream flowing from it. A few specimens also taken in Spring Creek, Tuscumbia, and in Veta Wright Creek, Decatur.

42. **Opsopœodus emiliæ** Hay.

A single example from Mallett's Creek.

43. **Notemigonus chrysoleucus** Mitchill.

Veta Wright Creek.

44. **Fundulus catenatus** Storer.

Cypress, Shoal, Pin Hook, and Richland Creeks.

45. **Fundulus albolineatus**, sp. nov. (Plate XLIII, fig. 1.)

Males blackish brown, the sides plumbeous, the rows of scales with interrupted whitish streaks, most conspicuous on hinder half of body. A black streak along middle line of back. Vertical fins dusky, the caudal becoming translucent on distal half, its margin abruptly and narrowly black-edged.

Females olivaceous, dusky on back, silvery below, the back and sides with narrow black lines following the rows of scales. Fins translucent, the dorsal sometimes with fine black specks at base, the caudal black-edged.

Head $3\frac{1}{3}$ to $3\frac{3}{5}$ in length; depth 4 to $4\frac{1}{2}$; least depth of caudal peduncle equals snout and two-thirds eye. Lat. l. 42; D. 10 or 11; A. 10 or 11; B. 5.

Teeth sharp, wide-set, in a broad band on premaxillaries, a narrow band on mandible. Snout one-third length of head. Width of interorbital space $2\frac{1}{4}$ to $2\frac{1}{3}$ in head.

Dorsal and anal opposite, or the dorsal slightly in advance, their bases equal and short, equaling length of snout and half eye. In males both fins become elevated, the longest anal ray equaling two-thirds head, and the anal rays become covered with prickles. In males the pectorals reach the ventrals, and the ventrals to or nearly to vent. Both are much shorter in females.

Several specimens, the longest $3\frac{1}{3}$ inches, from Spring Creek, Huntsville, Ala.

46. **Zygonectes notatus** Raf.
Everywhere abundant.

47. **Lucius vermiculatus** LeSueur.
Courtland, Hillsborough, and Decatur, Ala.

48. **Lucius reticulatus** LeSueur.
Cypress and Nance Creeks.

49. **Labidesthes sicculus** Cope.
Abundant at Florence, Tuscumbia, and Courtland.

50. **Aphredoderus sayanus** Gilliams.
A single specimen from Cypress Creek.

51. **Pomoxys sparoides** Lacépède.
Mallett's, and Veta Wright Creeks.

52. **Ambloplites rupestris** Raf.
Florence, Courtland, and Pulaski.

53. **Chænobryttus gulosus** C. & V.
Cypress, and Mallett's Creeks.

54. **Lepomis pallidus** Mitchill.
Generally abundant.

55. **Lepomis megalotis** Raf.
Everywhere abundant.

56. **Micropterus dolomieu** Lacépède.
Cypress Creek.

57. **Micropterus salmoides** Lacépède.
Abundant; generally distributed.

58. **Etheostoma nigrum** Raf.
Cypress Creek, and Spring Creek at Tuscumbia.

59. **Etheostoma stigmæum** Jordan. (=*Etheostoma saxatile* Hay).
This species is widely distributed throughout the basins of the Cumberland, Tennessee, Escambia, Alabama, and Pascagoula Rivers, and will doubtless be found in other Gulf rivers. It has also been taken in Arkansas. Comparison of *saxatile* with the type of *stigmæum*, and with additional material from the Coosa River, has shown their identity. Specimens are in the present collection from Cypress Creek and Big Nance.

60. **Etheostoma simoterum** Cope.
Everywhere very abundant. Along this portion of the Tennessee the most widely distributed and generally abundant of the darters.

61. **Etheostoma blennius** Gilbert and Swain.
Three additional specimens of this species were secured in Cypress Creek, and disagree with the original description in the following details: The dark bar before dorsal is narrower and does not cover all of nape. The eye in these smaller specimens is $4\frac{1}{4}$ in head. The width of branchiostegal membranés equals two-thirds distance from its anterior attachment to tip of lower jaw. The profile from nape to middle of interorbital space is gently declined, and the dorsal outline of body is more strongly arched than the ventral.

62. **Etheostoma blennioides** Raf.
Cypress and Shoal Creeks at Florence, and the Big Nance at Courtland.

63. **Etheostoma caprodes** Raf.
Generally abundant.

64. **Etheostoma scierum** Swain.
Three specimens from Spring Creek, Courtland.

65. **Etheostoma aspro** Cope & Jordan.
Not abundant. Taken at Tuscumbia and Hillsborough.

66. **Etheostoma evides** Jordan.
Rare. Two specimens from Duck River at Columbia, Tenn.

67. **Etheostoma zonale** Cope.
Not abundant in tributaries of the Bend of the Tennessee. Taken in Cypress and Shoal Creeks and in the Big Nance.

68. **Etheostoma maculatum** Kirtland.
A few small specimens from Cypress Creek and Duck River.

69. **Etheostoma rufolineatum** Cope.
Not common. Taken in Cypress and Shoal Creeks, Florence.

70. **Etheostoma flabellare** Raf.
Huntsville and Florence; rare.

71. **Etheostoma squamiceps** Jordan.
Generally abundant and reaching a large size.

72. **Etheostoma cœruleum** Storer.
Very rare. Found only in Cypress Creek and at Tuscumbia.

73. **Etheostoma tuscumbiæ** Gilbert & Swain.
Very abundant at Tuscumbia. A few specimens found in Veta Wright Creek, Decatur.

74. **Cottus bairdi** Girard.
Generally abundant in clear cold streams.

Distribution of the species taken in the tributaries of the Bend of the Tennessee River.

	Pin-Hook Creek and Spring Branch, Huntsville.	Veta Wright Creek, Decatur.	Mallett's Creek, Hillsborough.	Spring Creek, and Big Nance, Courtland.	Spring Creek, Tuscumbia.	Cypress Creek, Florence.	Shoal Creek, Florence.	Duck River, Columbia, Tenn.	Richland and Pigeon Roost Creeks, Pulaski, Tenn.
Lepidosteus osseus									+
Noturus miurus								+	
Noturus exilis						+			+
Noturus flavns							+		
Ameiurus melas	+								
Ameiurus natalis		+	+						
Ictalurus punctatus				+				+	
Ictiobus bubalus*									
Carpiodes difformis									+
Catostomus teres	+	+	+	+	+	+			
Catostomus nigricans	+			+	+				+
Erimyzon sucetta		+				+			
Minytrema melanops		+	+	+	+				
Moxostoma macrolepidotum	+			+	+	+		+	+
Moxostoma anisurum				+					+
Lagochila lacera						+			+
Campostoma anomalum	+	+	+	+	+	+			+
Chrosomus erythrogaster						+			
Hybognathus nucbalis	+	+		+	+				
Pimephales notatus	+		+	+	+	+		+	+
Cliola vigilax					+				+
Notropis spectrunculus				+					
Notropis deliciosus				+					
Notropis whipplei			+	+		+	+	+	+
Notropis galacturus					+		+	+	+
Notropis megalops	+	+	+	+	+	+		+	
Notropis coccogenis					+				
Notropis ariommus						+			
Notropis boöps		+		+		+			
Notropis leuciodus				+		+			
Notropis umbratilis fasciolaris	+		+	+	+	+		+	+
Notropis micropteryx							+		
Ericymba buccata						+			
Phenacobius uranops				+		+	+	+	+
Rhinichthys atronasus	+					+			
Hybopsis kentuckiensis			+			+		+	
Hybopsis dissimilis							+		
Hybopsis amblops				+	+	+		+	+
Hybopsis monacbus							+		
Semotilus atromaculatus	+	+			+				
Phoxinus vittatus	+	+			+				
Opsopœodus emiliæ			+						
Notemigonus chrysoleucus		+							
Fundulus catenatus	+					+			+
Fundulus albolineatus	+								
Zygonectes notatus		+	+	+	+	+			
Lucius vermiculatus		+	+	+					
Lucius reticulatus				+		+			
Labidesthes sicculus				+	+	+			
Aphredoderus sayanus						+			
Pomoxys sparoides		+	+						
Ambloplites rupestris				+		+	+		+
Chænobryttus gulosus			+			+			
Lepomis pallidus		+	+	+	+	+			
Lepomis megalotis	+	+	+	+	+	+			+
Micropterus dolomieu						+			
Micropterus salmoides		+	+	+	+	+			
Etheostoma nigrum					+	+			
Etheostoma stigmæum				+		+			
Etheostoma simoterum	+	+	+	+	+	+	+	+	+
Etheostoma blennius						+	+		
Etheostoma blennioides				+		+	+		
Etheostoma caprodes			+	+	+	+		+	+
Etbeostoma scierum				+					
Etheostoma aspro			+		+				
Etheostoma evides								+	
Etheostoma zonale				+		+	+		
Etheostoma maculatum						+		+	
Etheostoma rufolineatum						+	+		
Etheostoma flabellare	+						+		
Etheostoma squamiceps	+	+	+	+	+	+			+
Etheostoma cœruleum					+	+			
Etheostoma tuscumbiæ		+			+				
Cottus bairdi	+		+	+	+	+			+

* Tennessee River at Florence.

B.—The Alabama Basin.

1. **Lepidosteus osseus** L.

Black Warrior River, Tuscaloosa.

2. **Noturus leptacanthus** Jordan.

Oxford and Helena.

3. **Noturus funebris** Gilbert & Swain, sp. nov.

Body elongate, the head slender, comparatively little depressed, not tapering rapidly towards tip of snout. Mouth of moderate size, the cleft very convex forwards, the upper lip heavy and projecting distinctly beyond it. Width of gape, $1\frac{4}{5}$ in head. Premaxillary band of teeth short and broad, without lateral backward processes. Barbels all slender and threadlike, that of maxillary extending beyond base of pectoral spine. Outer mental barbels extending much beyond margin of branchiostegal membranes, equaling length of head anterior to preopercle. Nasal barbels when laid back reach to posterior point of opercle. Eyes very small, two-fifths length of snout, one-third width of interorbital space, which is slightly less than one-half head. Eye about 7 in head.

Spines slender and short. The pectoral spines one-half longest pectoral ray, and one-third length of head; they are roughened without and have three or four small weak teeth on inner margin. Distance from snout to front of dorsal, $2\frac{2}{3}$ in length. Dorsal spine less than half longest ray, which is about half length of head. Caudal rounded, its rudimentary rays very strongly developed, extending along under side of tail to base of anal fin, and along upper side to slightly beyond this point. Adipose fin well developed, forming a conspicuous notch where it joins rudimentary caudal rays. Ventrals to beyond front of anal. — counting last 2 as 2 vs

Head 4 in length; depth $5\frac{1}{2}$. D. I, 6; A. 23 (in four specimens), its base two-sevenths length; length $3\frac{1}{2}$ inches.

Color of body and fins uniform brownish-black, the belly uniform dusky. Barbels black.

*Four specimens of this species were taken during the summer of 1884 in a spring run tributary to North River, near Tuscaloosa, Ala.

4. **Ameiurus melas** Raf.

Black Warrior River, Tuscaloosa.

5. **Ameiurus natalis** LeSueur.

Abundant in a pond fed by springs at Tuscaloosa.

6. **Ictalurus punctatus** Raf.

Clear Creek, Attalla, and Hoglan's Creek at Warrior Station.

7. **Catostomus nigricans** LeSueur.

Generally abundant.

8. **Moxostoma macrolepidotum duquesnei** LeSueur.

Abundant.

9. **Moxostoma pœcilurum** Jordan.

A single specimen from Clear Creek, Attalla.

10. **Placopharynx carinatus** Cope.

Tuscaloosa. Apparently not rare.

11. **Erimyzon sucetta** Lacépède.

Calera and Cullman, Ala.

[illegible] USNM 36616

12. **Minytrema melanops** Raf.
Choccolo Creek, Oxford.

13. **Campostoma anomalum** Raf.
Generally distributed.

14. **Hybognathus nuchalis** Agassiz.
Tuscaloosa. I am unable to distinguish *hayi* from *nuchalis.*

15. **Pimephales notatus** Raf.
Hoglan's Creek, Warrior.

16. **Cliola vigilax** Baird and Girard.
Tuscaloosa and Attalla; not abundant.

17. **Notropis venustus cercostigma** Cope.
Exceedingly abundant. There is a recognizable difference between Texan and Alabaman specimens of *venustus*. The latter have a more elongate body, darker coloration, and the caudal spot more elongate, extending farther back on median caudal rays. The scales average a trifle smaller, 40 or 41 instead of 38 or 39, the range of variation being from 37 or 38 to 42 in both forms. Typical *venustus* have the caudal spot nearly circular.

18. **Notropis callistius** Jordan.
This species is abundant throughout the Alabama basin, of which it is apparently characteristic.

19. **Notropis trichroistius** Jordan and Gilbert.
Everywhere accompanying *callistius*, which this species very strongly resembles. It may apparently be distinguished by its larger oblique mouth and sharp nose.

20. **Notropis cœruleus** Jordan.
This beautiful species is seemingly not abundant. Specimens were secured at Attalla and Oxford.

21. **Notropis megalops** Raf.
Generally abundant.

22. **Notropis chrosomus** Jordan.
Found abundant in a small creek tributary to the Black Warrior River near Tuscaloosa. Not taken elsewhere.

23. **Notropis xænocephalus** Jordan.
Generally abundant, and easily distinguished by the conspicuously checkered appearance of the back, owing to the darker margins of the scales. Adults show a well-marked lateral band, which may pass around the snout.

24. **Notropis stilbius** Jordan.
Everywhere abundant. Always showing a cluster of black dots at base of caudal, which may form a conspicuous black spot. To specimens with such a spot, was given the manuscript name *Notropis spilurus*, Gilbert and Swain, in Jordan's Catalogue of Fishes N. A., page 26.

25. **Phenacobius catostomus** Jordan.
Big Cahawba at Helena. Very close to *P. uranops*, with which it agrees in size of head (4½ to 5 in length) and in width of isthmus (2½ to 3 in head). It differs in its deeper head and body, and in its much thinner lips.

26. **Hybopsis kentuckiensis** Raf.
At Chestnut Creek, Verbena; not abundant.

27. **Hybopsis amblops rubrifrons** Jordan.

Attalla, Oxford, and Helena; apparently not abundant.

28. **Hybopsis hyostomus** Gilbert.

Abundant at Tuscaloosa and at Oxford. Agreeing perfectly with types of the species from Indiana.

29. **Semotilus atromaculatus** Mitchill.

Abundant. Scales 55 and 56.

30. **Notemigonus chrysoleucus** Mitchill.

Tuscaloosa and Calera.

31. **Fundulus stellifer** Jordan.

Attalla, Oxford, and Helena. Adult males with very conspicuous broad jet-black margins to vertical fins.

32. **Zygonectes notatus** Raf.

Black Warrior River at Tuscaloosa and Morris, and Hoglan's Creek, Warrior.

33. **Lucius reticulatus** LeSueur.

Tuscaloosa and Helena.

34. **Tylosurus marinus** Bloch and Schneider.

A specimen, measuring about a foot long, was taken in the Black Warrior River at Tuscaloosa.

35. **Lepomis pallidus** Mitchill.

Generally distributed, but less abundant than the next.

36. **Lepomis megalotis** Raf.

Everywhere common.

37. **Micropterus salmoides** Lacépède.

38. **Micropterus dolomieu** Lacépède.

39. **Etheostoma beani** Jordan.

Tuscaloosa.

40. **Etheostoma asprellum** Jordan.

Choccolo Creek, Oxford. A single specimen.

41. **Etheostoma stigmæum** Jordan.

Generally abundant.

42. **Etheostoma simoterum** Cope.

Abundant in the Alabama basin, and varying more or less from the typical form.

43. **Etheostoma blennioides** Raf.

Big Cahawba, Helena. The form is somewhat more slender in these Southern specimens, and the V-shaped markings are less distinct and regular than in Northern specimens.

44. **Etheostoma copelandi** Jordan. (= *Etheostoma putnami* Jordan & Gilbert.)

Abundant in the Black Warrior at Tuscaloosa. Specimens of this species recently collected by Dr. J. A. Henshall at Put-in-Bay, Ohio, have scales varying from 47 to 52; others from New Harmony, Indiana, vary from 46 to 51. In the Alabama specimens the lateral line averages 53. I am thus unable to longer distinguish *putnami* (characterized by its larger scales) from *copelandi*.

45. **Etheostoma caprodes** Raf.

Everywhere abundant.

46. **Etheostoma nigrofasciatum** Agassiz.

Generally abundant.

47. Etheostoma rupestre Gilbert & Swain.

North River near Tuscaloosa.

48. Etheostoma (Nothonotus) jordani, sp. nov. (Plate XLIII, fig. 2.)

Closely related to *E. rufolineatum*, from which it differs conspicuously in form and coloration.

Body rather deep, compressed, the caudal peduncle slenderer than in related forms, the anterior profile much more convexly decurved, the snout blunter.

Mouth terminal, oblique, rather small, the maxillary scarcely reaching vertical from front of pupil, $3\frac{2}{5}$ in head. Premaxillaries on level of lower margin of orbit, the jaws about equal. Eye equaling snout, $4\frac{1}{3}$ to $4\frac{1}{2}$ in head, twice interorbital width. Preopercle entire. Gill membranes not united.

Spinous dorsal high, the spines strong, the membrane from last spine not joining base of soft dorsal; highest dorsal spine slightly more than half length of head. Base of soft dorsal $1\frac{1}{2}$ in base of spinous dorsal. Anal shorter than soft dorsal, and inserted more anteriorly, the first spine longer and stronger than the second, two-thirds the height of longest anal ray, and one-third length of head. Caudal fan-shaped when widely spread. Pectorals reaching beyond tips of ventrals, $1\frac{1}{4}$ in head; ventrals extending half way to base of second anal spine.

Scales large, strongly ctenoid, present on nape, the breast naked; opercles scaly, head otherwise naked. No enlarged black humeral scale. Lateral line complete, or wanting on occasional scales in its course, straight.

Head $3\frac{1}{2}$ to $3\frac{3}{4}$ in length; depth $4\frac{3}{4}$ to 4. D. x or xi–10 to 12; A. I. 7 or 8; Lat. l. 43 to 55 (averaging 48).

Colors probably brilliant in life. In spirits, the males are olivaceous, darker above, the sides, with faint, narrow longitudinal dark lines running between the rows of scales. Back with 8 black cross-bars wider than the interspaces; the first on nape, the second under and in advance of origin of spinous dorsal, the fifth under first rays of soft dorsal. The first bar is continued downwards into axil of pectorals, the others usually not reaching lateral line. Middle of sides with irregular bars usually formed of disconnected blotches, and 9 or 10 in number. A pair of black blotches at base of median caudal rays, and sometimes a pair at base of outer rays. Fin rays all blackish, the membranes lighter. Basal half of anterior portion of spinous dorsal black, its margin narrowly white, a narrow submarginal dark line below it. Soft dorsal and caudal with a wide white (probably orange in life) submarginal band, the tips narrowly black. Anal and ventrals similar, but without black margin. Pectorals uniform dusky, with light membranes. Snout and top of head blackish; a small black spot behind eye. Fins probably blue and orange in life. Females mottled, with fins barred. Abundant in Choccolo Creek, Oxford, and Chestnut Creek, Verbena.

49. Etheostoma squamiceps Jordan. (=*Etheostoma parvipinnis* Gilbert & Swain.)

This widely distributed species varies extremely in appearance, in number of fin-rays, and in squamation. Specimens from the Alabama basin (*parvipinnis*) are usually smaller, with less elevated fins and fewer fin-rays, but seem to vary perfectly into the typical form.

From Calera.

50. Etheostoma whipplei alabamæ Gilbert & Swain.

Abundant in tributaries of the Black Warrior River. Also taken in the Big Cahawba, at Helena.

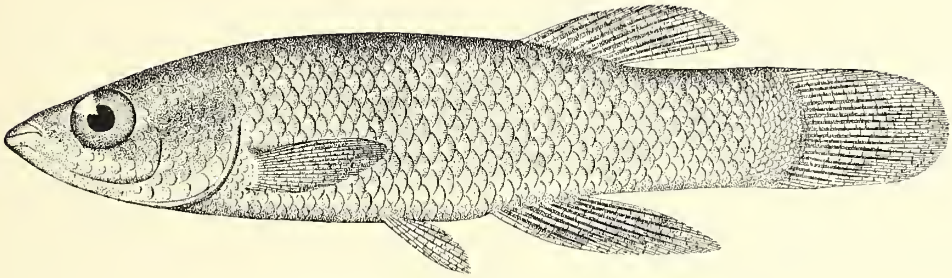


FIG 1. FUNDULUS ALBOLINEATUS. (About twice natural size.)

(See page 149.)

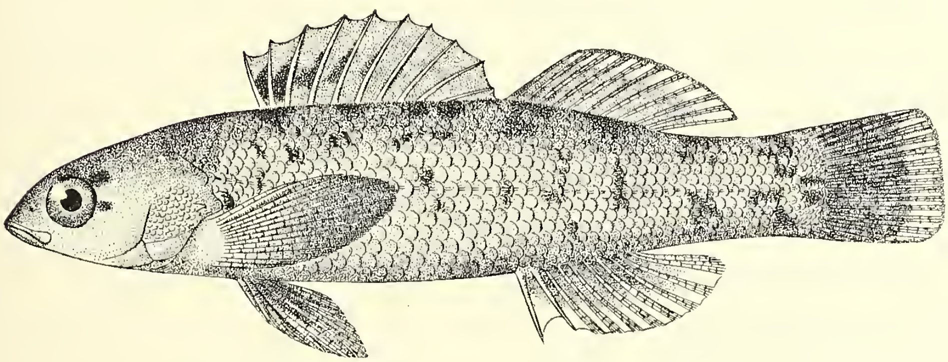


FIG. 2. ETHEOSTOMA JORDANI Gilbert (About 2¼ times natural size.)

(See page 156.)

51. **Cottus bairdi** Girard.

Big Cahawba River at Helena; Clear Creek and Will's Creek, Attalla; Choccolo Creek at Oxford.

Distribution of the species taken in the tributaries of the Alabama River.

	Eight-mile creek, Cullman.	Mulberry Fork, Blount Springs.	Black Warrior River at Warrior Station and Morris.	Black Warrior River and North River, Tuscaloosa.	Big Cahawba River, Helena.	A small creek at Calera.	Clear Creek, Will's Creek, Attalla.	Choccolo Creek, Oxford.	Chestnut Creek, Verbena.
Lepidosteus osseus				+					
Noturus leptacanthus					+			+	
Noturus funebris				+					
Ameiurus melas				+					
Ameiurus natalis				+					
Ictalurus punctatus			+				+		
Catostomus nigricans		+			+		+	+	+
Moxostoma macrolepidotum duquesnei	+		+	+	+		+	+	
Moxostoma pœcilurum							+		
Placopharynx carinatus				+					
Erimyzon sucetta	+					+			
Minytrema melanops								+	
Campostoma anomalum	+	+		+	+			+	+
Hybognathus nuchalis				+					
Pimephales notatus			+						
Cliola vigilax				+			+		
Notropis venustus cercostigma	+	+		+	+		+	+	+
Notropis callistius		+	+	+	+			+	+
Notropis trichroistius		+	+	+	+			+	+
Notropis cœruleus							+	+	
Notropis megalops				+	+	+	+	+	+
Notropis chrosomus				+					
Notropis xænocephalus	+		+	+		+			
Notropis stilbius	+		+	+	+		+	+	
Phenacobius catostomus					+				
Hybopsis kentuckiensis									+
Hybopsis amblops rubrifrons					+		+	+	
Hybopsis hyostomus				+				+	
Semotilus atromaculatus	+	+		+		+			
Notemigonus chrysoleucus				+		+			
Fundulus stellifer					+		+	+	
Zygonectes notatus			+	+					
Lucius reticulatus				+	+				
Tylosurus marinus				+					
Lepomis pallidus	+		+	+		+		+	
Lepomis megalotis	+	+	+	+	+	+	+		+
Micropterus salmoides		+		+	+	+		+	
Micropterus dolomieu		+			+				+
Etheostoma beani				+					
Etheostoma asprellum								+	
Etheostoma stigmæum			+	+	+		+	+	+
Etheostoma simoterum		+	+		+		+		
Etheostoma blennioides					+				
Etheostoma copelandi				+					
Etheostoma caprodes	+	+	+	+	+		+	+	+
Etheostoma nigrofasciatum			+	+	+	+	+	+	+
Etheostoma rupestre				+					
Etheostoma jordani								+	+
Etheostoma squamiceps						+			
Etheostoma whipplei alabamæ			+	+	+				
Cottus bairdi					+		+	+	

C.—ESCAMBIA RIVER.

1. **Noturus leptacanthus** Jordan.

Little Escambia, Hawkins Creek, and Sandy Creek.

2. **Erimyzon sucetta** Lacépède.

Black Creek and Escambia River at Flomaton.

3. Minytrema melanops Raf.
Sandy Creek and Escambia River at Flomaton.

4. Pimephales notatus Raf.
Persimmon Creek.

5 Ericymba buccata Cope.
Sandy Creek and Escambia River at Flomaton.

6. Notropis longirostris Hay.
Persimmon Creek. Several specimens of a small blunt-headed silvery minnow, agreeing perfectly with Hay's description, excepting the dentition, which is 1—4—4—1, or 1—4—4—0.

7. Notropis venustus cercostigma Cope.
Little Escambia, Hawkins Creek, Persimmon Creek, Sandy Creek, and Escambia River at Flomaton.

8. Notropis xænocephalus Jordan.
Sandy Creek and Escambia River at Flomaton.

9. Notropis roseipinnis Hay.
Hawkins Creek, Persimmon Creek, and Sandy Creek.

10. Notropis metallicus Jordan & Meek.
Sandy Creek. A single specimen of this interesting species, not previously seen since its original description from the Altamaha River, Georgia.

11. Notemigonus chrysoleucus Cuv. & Val.
Hawkins Creek and Escambia River near its mouth.

[12. Clupea chrysochloris Raf.]
Escambia River near its mouth.

[13. Clupea sapidissima Wilson.]
Escambia River near its mouth.

[14. Dorosoma cepedianum Le Sueur.]
Escambia River near its mouth.

15. Gambusia patruelis B. & G.
Black Creek.

16. Fundulus stellifer Jordan. W.
Will's Creek.

17. Zygonectes notatus Raf.
Little Escambia, Will's Creek, Hawkins Creek, Persimmon Creek, and Sandy Creek.

18. Zygonectes guttatus Agassiz. (=*Zygonectes escambiæ* Bollman.)
Black Creek and Escambia River at Flomaton.

19. Zygonectes cingulatus Cuv. & Val.
Little Escambia, Black and Will's Creek, Escambia River at Flomaton and near its mouth.

I follow Mr. Bollman in his identification of this species with the *Fundulus cingulatus* of Cuvier and Valenciennes, on the strength of notes taken by Dr. Jordan from the original types. The original description of *cingulatus* would be insufficient identification.

20. Lucius americanus Gmelin.
Hawkins Creek. The easternmost record for this species.

21. **Lucius reticulatus** Le Sueur.
Little Escambia and Escambia River at Flomaton.

22. **Lucius vermiculatus** Le Sueur.
Black and Sandy Creeks.

23. **Anguilla anguilla chrisypa** Raf.
Will's Creek.

24. **Labidesthes sicculus** Cope.
Will's Creek.

[25. **Pomoxys sparoides** Lacépède.]
Escambia River near its mouth.

26. **Chænobryttus gulosus** Cuv. & Val.
Hawkins Creek and Escambia River near its mouth.

27. **Lepomis pallidus** Mitchill.
Black, Will's, Hawkins and Sandy Creeks; Escambia River near its mouth.

28. **Lepomis megalotis** Raf.
Little Escambia; Black, Will's, Hawkins, Persimmon, and Sandy Creeks; Escambia River near Flomaton.

[29. **Lepomis holbrooki** Cuv. & Val.] E.
Escambia River near its mouth.

30. **Micropterus salmoides** Lacépède.
Little Escambia; Black, Will's, Hawkins and Sandy Creeks; Escambia River near its mouth.

31. **Etheostoma beani** Jordan.
Little Escambia; Hawkins, Persimmon, and Sandy Creeks; Escambia River at Flomaton.

32. **Etheostoma simoterum** Cope.
Sandy Creek.

33. **Etheostoma uranidea** Jordan & Gilbert.
Several specimens from the Little Escambia at Pollard. These are slender and pale, but do not otherwise differ from northern specimens.

34. **Etheostoma nigrofasciatum** Agassiz.
Little Escambia; Will's, Hawkins, Persimmon, and Sandy Creeks; Escambia River at Flomaton.

35. **Etheostoma squamiceps** Jordan.
Little Escambia; Will's and Sandy Creeks; Escambia River at Flomaton.

36. **Etheostoma prœliaris** Hay. L.
Little Escambia. Lateral line developed on 3 or 4 scales. Anal spines two.

[37. **Roccus lineatus** Bloch.]
Escambia River near its mouth.

38. **Cottus bairdi** Girard.
Will's Creek.

INDIANA UNIVERSITY,
Bloomington, Ind., April 23, 1891.

11.—NOTES ON AN IMPROVED FORM OF OYSTER TONGS.

BY HUGH M. SMITH.

(With plate XLIV.)

With the threatened exhaustion of the shoaler oyster beds in the Chesapeake, resulting in a greatly diminished yearly output, and a consequent diminution in the earnings of oystermen, especially those operating with tongs from small open boats, the introduction of an apparatus which will enable the fishermen to take oysters from the deepest waters of the Chesapeake basin must be a great boon to those dependent on the industry, and also the means of materially promoting the fishery interests of the region.

For a number of years it has been anticipated that the time would come when the oyster fishery with tongs on all natural beds would have to be discontinued in many portions of the Chesapeake, owing to overfishing and the eventual depletion of the grounds. In that event the only alternatives which had generally suggested themselves were the abandonment of the fishery or the allotment by the States interested of oyster lands in perpetuity to individual parties, as is done in other States, notably Connecticut.

Fortunately, as regards the first alternative at least, the invention of the apparatus to be described has apparently made the profitable continuance of the tong fishery possible for some time to come, and has temporarily relieved the States from the necessity for legal enactments in the direction indicated, which but for this could not have been much longer delayed.

It has long been known that vast oyster beds exist in the deeper portions of the Chesapeake and the rivers tributary thereto, which, owing to the greater and hitherto seemingly insurmountable difficulty in working them, have escaped the ravages of both tongers and dredgers. These have now become available through the use of the so called deep-water oyster tongs.

With the ordinary type of oyster tongs, provided as they are with wooden handles, the greatest depth at which oysters can be taken is only 25 or 30 feet, and even then the work is not satisfactory, and very arduous. A depth of water beyond 15 or 20 feet in which to employ tongs has never been much sought after by oystermen, while it is probable that the great bulk of the tonged oysters which find their way to market are taken from less than 15 feet of water.

With this explanation it can readily be seen that the use of the ordinary tongs is comparatively limited, in view of the fact that oysters often occur in the deepest waters of the inshore basins, along the middle and southern portions of the Atlantic seaboard.

In the new tongs, the long, cumbersome pole handles are done away with, and a single rope is substituted. This point of course overcomes the one great objection to the old tongs—that the latter are suited only for shallow water. The advantage of the new form shows itself in the next improvement, made necessary by the withdrawal of the lever-like action of the handles in approximating the two series of teeth. In order to compensate for the absence of leverage by handles, it was required that some modification should be made in the structure of the arms and teeth. This was brought about in the way indicated in the accompanying illustration, which exhibits a pair of deep-water tongs as they would appear when first reaching bottom.*

The new tongs consist of two curved iron bars so riveted together near the middle as to permit of free motion on each other, and attached on one extremity to the teeth and cradles, and on the other to the rope by which the apparatus is lowered and raised. Immediately beneath the crossing point of the two arms a weight is suspended, which plays an important part in the workings of the tongs. To the upper bar of one side, an iron link or loop is attached by means of a staple, and on the lower bar, just below the link, is a small iron peg or stud, over which the link fits when the teeth are separated to their greatest extent. When the oystering begins, the arms are "locked," as indicated, by means of the loop and peg, and lowered over the side of the boat or vessel until the bottom is reached. If it be ascertained by gently raising and lowering the apparatus that the bottom is probably covered with oysters, the tongs are suddenly dropped from the height of a few feet from the bottom, and by virtue of the presence of the weight referred to the loop slips off the pin and the teeth will then approach each other when the rope is hauled taut.

The weights on the ends of the arms, as shown in the figure, are not always present; and, under certain similar conditions, the middle line, running from the crossing point of the arms to the top of the bridle, and on up to the boat, can also be dispensed with. When these two adjuncts are employed, it is possible to operate the tongs without the aid of the middle weight and the loop-and-peg attachment.

In very shallow water, and where oysters are not plentiful, the middle weight is removed and the apparatus is lowered to the bottom by the use of the middle line, the tongs being kept open by the adjustable weights on the arms, without the intervention of the loop. In raising the tongs, the middle line is slackened and the teeth are brought together and kept closed by drawing on the rope that is attached to the upper part of the bridle.

Where the fishery is carried on in very deep water or oysters lie thickly on the bottom, both the middle line and arm weights are removed, and the middle weight and loop are alone employed. The tongs are locked in an open position and thrown overboard. When the apparatus strikes the bottom the link is automatically tripped or jolted off the pin, and the tongs are then closed by means of the single line going to the bridle.

The piece of iron in the center varies from 12 to 30 pounds in weight. The greater weight is employed in deep water and strong currents, while less is required in shallow and still water.

The great simplicity of this apparatus increases its value in no small degree.

* The figure shows the tongs rigged for both deep and shallow water, with weights on the arms and in the middle. The use of these is explained.

The only possible objection to it is that it is necessarily heavier than the ordinary tongs, and in very deep water requires the use of a small windlass attached to the mast or elsewhere on the boat from which it is being operated. With this adjunct it is said that even a small boy can manage it with ease.

These tongs were first employed in 1885–'86 from Solomon's Island, Maryland, where they came into general use during the season of 1887–'88, when it is estimated that two-thirds of the oystermen in that vicinity were provided with them. Up to the present time but few are employed elsewhere in the Chesapeake Bay, although it can be predicted that they will eventually become almost universally used throughout that region. The deep-water tongs can be readily operated in over 300 feet of water.

At St. George's Island, Maryland, near the mouth of the Potomac River, one of the few other localities in which the apparatus has been tested, one pair was operated in the fall of 1890 in water as deep as 120 feet with much success, the owner having no difficulty in stocking $25 daily, whereas, with the old tongs, $5 was considered very good remuneration for a day's work.

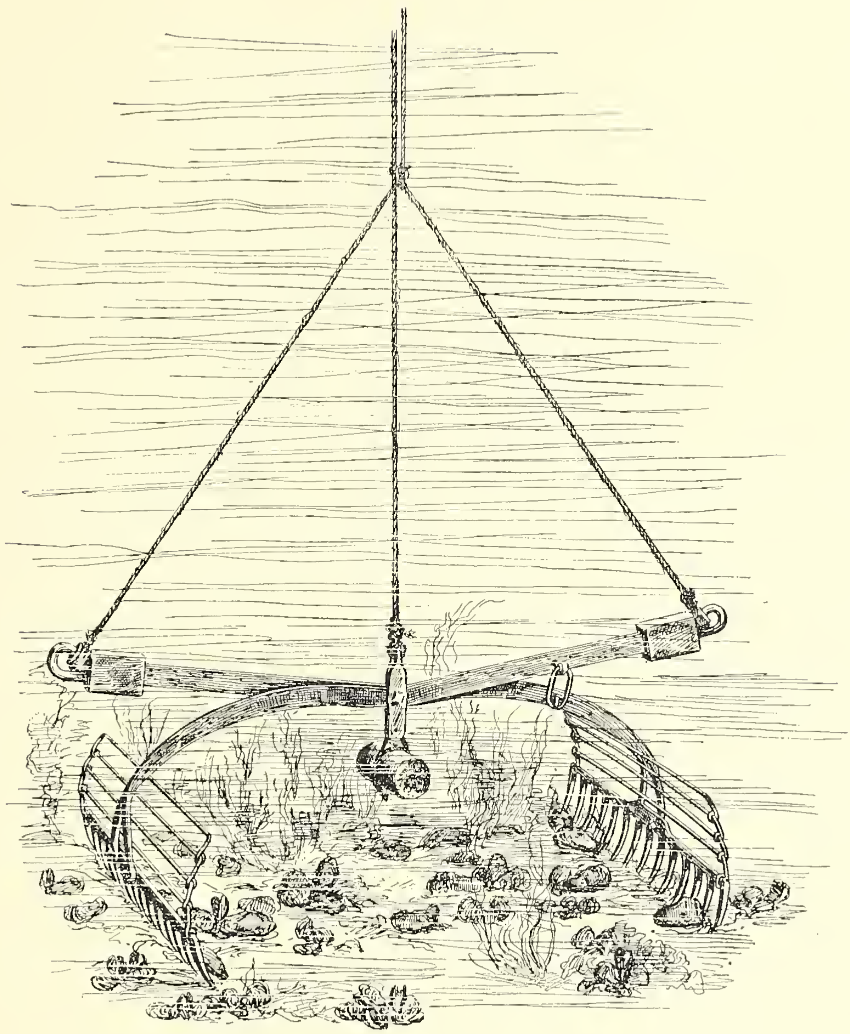
There are said to be large hitherto undisturbed beds in the middle of the Potomac River which are no doubt destined to yield handsome returns. Similar reports of the efficacy of the tongs and the opening up of new grounds come from other places in which the apparatus has been tried.

The following extract from a letter written by the inventor, Mr. Charles L. Marsh, of Solomon's Island, Maryland, dated September 18, 1890, will give some additional information concerning the advantages of his device:

> The difference in the catch between my tongs and the old tongs is perfectly astonishing. On beds or bars where oysters are plentiful, from 3 pecks to a bushel of oysters can be gathered at each filling, and from 30 to 100 bushels caught per day. With the old tongs from 8 to 25 bushels per day is regarded to be a good catch.
>
> I have manufactured, and licensed others to manufacture, about twelve hundred pairs of tongs since the issuing of letters patent to me, in December, 1887, an average of about four hundred pairs per year. The tongs, with the clamps, blocks, weights, and all necessary equipments, are worth $16 per pair. My tongs are successfully operated where the old tongs, with handles, can not be used, viz., in any depth of water where oysters grow, *i. e.*, from 30 to 200 feet. Hence the value and advantage of my tongs over the old ones, in taking oysters in deep water where they could not be reached by tongmen before my invention. The greater the depth of water the greater the catch, from the fact that oysters in deep water have remained undisturbed for many years for the want of a proper machine like mine to reach them. Another advantage of my tongs is the cultivating and enlarging of the deep-water bars, whereby the oysters are becoming as profitable to the tongmen in deep water, as heretofore in the creeks and coves.

Information from other sources, some of which I have gathered in personal interviews with fishermen, so fully substantiates the above statements that there seems to be ample justification in quoting them, especially in view of the important beneficial influence the dissemination of these facts may have upon the shellfish fisheries.

The principle involved in these tongs is of wide application in the molluscan fisheries. In addition to being adapted to all deep-water beds of oysters, it is apparently admirably suited for scallop and clam fishing in deep water, where the present methods are unsatisfactory or impossible. Some modification in the teeth and carrying portion might be necessary in order to make the tongs suitable for the capture of other mollusks, although it is reported that the fishermen of Back River, Virginia, have found the apparatus, as already described, to be very efficacious in taking clams (*Venus mercenaria*) in water too deep for the ordinary tongs.



DEEP WATER OYSTER TONGS.

(See page 161.)

SEINING SALMON AT KARLUK, LOOKING SOUTHWEST. CANNERIES OF KARLUK PACKING COMPANY (LEFT) AND ALASKA IMPROVEMENT COMPANY.

12.—REPORT ON THE SALMON AND SALMON RIVERS OF ALASKA, WITH NOTES ON THE CONDITIONS, METHODS, AND NEEDS OF THE SALMON FISHERIES.

BY TARLETON H. BEAN,
Ichthyologist, U. S. Fish Commission.

(With plates XLV–LXXIX.)

[Reprint of H. R. Mis. Doc. No. 211, Fifty-first Congress.]

LETTER OF TRANSMITTAL.

U. S. COMMISSION OF FISH AND FISHERIES,
Washington, D. C., June 6, 1890.

SIR: I have the honor to transmit herewith a report of an investigation of the habits, abundance, and distribution of the salmon of Alaska, as well as the present conditions of the fisheries and the methods employed in the prosecution of the same, such investigation having been made under the authority of Congress, as conveyed in section 2 of act approved March 2, 1889, and entitled "An act to provide for the protection of the salmon fisheries of Alaska," as follows:

* * * * * * *

SEC. 2. That the Commissioner of Fish and Fisheries is hereby empowered and directed to institute an investigation into the habits, abundance, and distribution of the salmon of Alaska, as well as the present conditions and methods of the fisheries, with a view of recommending to Congress such additional legislation as may be necessary to prevent the impairment or exhaustion of these valuable fisheries, and placing them under regular and permanent conditions of production.

* * * * * * *

No appropriation was made to cover the expenses of such investigation, but considering the act mandatory, and realizing the importance of placing before Congress at the earliest date practicable the information necessary to indicate the additional legislation required for the protection and maintenance of the river fisheries of Alaska, I arranged to provide for the expenses of the investigation out of the general appropriation for the propagation of food-fishes, and with the opening of the season placed a party of investigators in the field, with instructions to proceed directly to the island of Kadiak and, after a thorough study of the conditions and methods of the salmon fisheries there, to extend their investigations to Cook's Inlet and its affluents, if the brief season available for field investigation would permit.

Kadiak Island was selected as the initial point because the salmon fisheries there have at present the greatest development and importance and because there the impending destruction of the salmon fisheries is most evident and the flagrant abuses requiring the restraint of law most obvious.

Dr. T. H. Bean, the ichthyologist of the Commission, was placed in charge of the party, his previous knowledge of this region and his training as a naturalist and scientific observer having specially qualified him for this service. Associated with him were Mr. Livingston Stone, the superintendent of our California and Oregon salmon-hatching stations, and Mr. Franklin Booth, of San Francisco. Mr. Stone was charged with the duty of reporting upon suitable sites for hatching stations and Mr. Booth with the study of the topographical features of the region and the physical features of the different river basins. This party continued in the field to as late a period as the season permitted. By reason of the short time available for field work the investigation did not extend beyond the islands of Kadiak and Afognak. Here, however, the fisheries are best organized and most extensively prosecuted, and conclusions based upon the investigation of the salmon fisheries of this region will probably have general application.

As an introduction to the report proper I have presented and discussed in as concise form as practicable the results of the field investigation and submitted certain recommendations as to the additional legislation necessary to "place the salmon fisheries of Alaska under permanent conditions of production."

Very respectfully,

M. McDonald,
Commissioner.

Hon. Thomas B. Reed,
Speaker of the House of Representatives.

INVESTIGATION OF THE SALMON FISHERIES OF ALASKA.

INTRODUCTORY.

The marvelous abundance of several species of salmon in Alaskan waters has been long known, but in consequence of the remoteness of this region and its inaccessibility, the abundant supply in rivers nearer markets, and a disposition on the part of buyers to underrate Alaskan products, its fishery resources have not been laid under contribution for market supply until within a few years, during which we have seen, as the result of reckless and improvident fishing, the practical destruction of the salmon fisheries of the Sacramento and the reduction of the take on the Columbia to hardly one-third of what it was in the early history of the salmon-canning industry on that river. At present the streams of Alaska furnish the larger proportion of the canned salmon which find their way to the markets.

Whether these fisheries shall continue to furnish the opportunity for profitable enterprise and investment depends upon the policy to be inaugurated and maintained by the Government. Under judicious regulation and restraint these fisheries may be made a continuing source of wealth to the inhabitants of the Territory and an important food resource to the nation; without such regulation and restraint, we shall have repeated in Alaskan rivers the story of the Sacramento and the Columbia; and the destruction in Alaska will be more rapid because of the small size of the rivers and the ease with which salmon can be prevented from ascending them. For a few years there will be wanton waste of that marvelous abundance, which the fishermen—concerned only for immediate profit and utterly improvident of the future—declare to be inexhaustible. This season of prosperity will be followed by a rapid decline in the value and production of these fisheries, and a point will be eventually reached where the salmon-canning industry will be no longer profitable.

SPECIES OF SALMON OF ECONOMIC VALUE.

The species of salmon found in Alaska in quantities sufficient to constitute an economic resource are as follows:

(1) The Red Salmon (*Oncorhynchus nerka*).
(2) The King Salmon (*Oncorhynchus chouicha*).
(3) The Silver Salmon (*Oncorhynchus kisutch*).
(4) The Hump-back Salmon (*Oncorhynchus gorbuscha*).
(5) The Dog Salmon (*Oncorhynchus keta*).
(6) The Steel Head (*Salmo gairdneri*).
(7) The Dolly Varden (*Salvelinus malma*).

The species at present constituting the principal motive and object of canning operations is—

THE RED SALMON.

The southern limit of the range of this species is the Columbia River, in which it is known as the Blue Back Salmon. Its range extends northward to the Yukon River, and it makes its appearance in southern Alaskan waters early in June, the run beginning later as we proceed farther to the north. A succession of schools continue to arrive until August and, after tarrying a short time in the coast waters, begin to ascend to their spawning grounds, which are in the cold snow-fed lakes from which issue the head-waters of the streams that are frequented by this species for the purpose of reproduction. The run is confined chiefly to the smaller streams, such as the Karluk, in which they crowd in numbers absolutely incredible to one who is not an eye witness, and actually force each other out of the water in their eager struggles to reach the sources of the rivers and deposit their spawn.

THE KING SALMON

Is the principal canning species of the Columbia and other rivers of Oregon and California, but at present it has relatively little importance in the Alaskan salmon fisheries. It is distinctively the salmon of the larger rivers, like the Yukon, on which the canning industry has not yet attained much development. It is, however, an abundant species, and, with the growth of the canning industry on the larger rivers, will attain great commercial importance.

THE SILVER SALMON

Is in great request for canning in the Puget Sound region, but is not held in much esteem by the canners of Alaska, because it becomes soft very soon after its capture and can not be kept like the Red Salmon. It spawns in the fall of the year, but does not make its appearance on the coast until shortly before canning operations close for the season, and, consequently, the opportunity for natural reproduction is more favorable than for the Red Salmon and King Salmon. The species is abundant now, and under present conditions of the fisheries will doubtless maintain itself. The flesh, though not highly colored, is probably not inferior in table qualities to the Red Salmon, and in the future, with the extension of canning operations, it will doubtless be utilized more extensively than at present.

THE HUMP-BACK SALMON

Is the smallest, the most abundant, and most widely distributed species of the Alaskan salmon. It arrives on the coast of Kadiak from the 1st to the 10th of July, and continues to run for about five weeks, the height of the spawning season being early in August. It does not ascend far from salt water, and usually enters streams which are too shallow to cover its back fins. This species is not much used at present for canning purposes, but is dried by the natives in large quantities for winter use, and moderately large quantities are salted for the San Francisco and other markets. When fresh run its flesh is not inferior in edible qualities to the Red Salmon, and has a beautiful red color, but rapidly deteriorates after it enters the estuaries of the rivers. This species, from its abundance and wide distribution, will attain great commercial importance when its good qualities are better known.

THE DOG SALMON

occurs very abundantly in the small rivers and creeks of the islands and the main land. It makes its appearance at Kadiak about the middle of June and continues abundant for a month, after which the numbers rapidly diminish. It leaves the coast with the first appearance of ice. The flesh of this species will hardly ever be in request for canning, but it is one of the most important species to the natives, who dry it for winter use.

REPRODUCTION.

The species of salmon above enumerated, though differing in their seasons of reproduction and in their spawning habits and requiring different conditions and environment, are all subject to the constraint of one common law—they must have access to their natural spawning grounds in the rapids of the rivers or in the cold snow-fed lakes from which they issue—and in this natural law is to be found the suggestion of such legislation as may be necessary "to maintain the salmon fisheries under permanent conditions of production."

We must provide that reproduction, natural or artificial, shall be on such a scale as will compensate for natural waste and man's destructive agencies. This may be accomplished in several ways: First, by legislation prescribing and enforcing such regulations in the conduct of the fisheries as will permit the salmon to enter the rivers and ascend to their spawning grounds in sufficient numbers to maintain the supply by natural reproduction; second, by the artificial fertilization and hatching of eggs taken from salmon caught for the supply of the canneries and the distribution of the fry thus obtained to the streams and lakes, which are the natural feeding grounds of the young salmon for some months after hatching.

Existing legislation concerning the protection of the salmon dates from the Fiftieth Congress and provides for the accomplishment of the first of these objects in the act following:

[Public—No. 158.]

An act to provide for the protection of the salmon fisheries of Alaska.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the erection of dams, barricades, or other obstructions in any of the rivers of Alaska, with the purpose or result of preventing or impeding the ascent of salmon or other anadromous species to their spawning grounds, is hereby declared to be unlawful, and the Secretary of the Treasury is hereby authorized and directed to establish such regulations and surveillance as may be necessary to insure that this prohibition is strictly enforced and to otherwise protect the salmon fisheries of Alaska; and every person who shall be found guilty of a violation of the provisions of this section shall be fined not less than two hundred and fifty dollars for each day of the continuance of such obstruction.

Sec. 2. That the Commissioner of Fish and Fisheries is hereby empowered and directed to institute an investigation into the habits, abundance, and distribution of the salmon of Alaska, as well as the present conditions and methods of the fisheries, with a view of recommending to Congress such additional legislation as may be necessary to prevent the impairment or exhaustion of these valuable fisheries, and placing them under regular and permanent conditions of production.

Sec. 3. That section nineteen hundred and fifty-six of the Revised Statutes of the United States is hereby declared to include and apply to all the dominion of the United States in the waters of Behring Sea; and it shall be the duty of the President, at a timely season in each year, to issue his proclamation and cause the same to be published for one month in at least one newspaper if any such there be

published at each United States port of entry on the Pacific coast, warning all persons against entering said waters for the purpose of violating the provisions of said section; and he shall also cause one or more vessels of the United States to diligently cruise said waters and arrest all persons, and seize all vessels found to be, or to have been, engaged in any violation of the laws of the United States therein.

Approved, March 2, 1889.

Additional legislation should provide for an increased production of salmon by fish-cultural methods, thus avoiding the enormous waste of eggs and young fish under their natural conditions and repairing, to some extent, the injury caused by over-fishing. The prohibition of obstructions impeding or preventing the ascent of the salmon to their spawning grounds must be strictly enforced, and destructive methods of fishing prevented by Government agents at the fishing localities, or a system of leasing fishery privileges under fixed regulations should be inaugurated.

The great bulk of the salmon taken in Alaska at present are caught by seines, gill-nets, and traps, all of which have been used in a more or less injurious manner. The continual hauling of seines across and near river mouths prevents salmon approaching the spawning condition from entering the streams. Gill-nets have been sometimes set entirely across the channels of rivers, and many traps are reported which act as complete barriers to the ascending fish. The seining operations also entail great unnecessary waste of good material by hauling on the beaches large numbers of trout, salmon, and other food-fishes which are not utilized.

The enormous value of the Alaskan salmon fisheries furnishes a sufficient incentive for prompt action in fostering and preserving the canning industry. In 1889 the number of canneries in operation was thirty-six, representing an investment of nearly $4,000,000, and the products were valued at about $3,000,000. Sixty-six vessels, including thirteen steamers, were engaged in this trade. The industry furnishes remunerative employment for several thousand men.

Alaska is a most promising field for fish-cultural operations. An abundance of gravid salmon can be obtained in the vicinity of good harbors. Ample supplies of suitable water can be conveyed to hatching establishments by gravitation alone. Impassable natural obstructions are almost unknown. Streams which are not subject to great fluctuations of level abound. The climate is favorable. Pollutions are absent. Labor and materials are cheap, and communication with ports in the United States is sufficiently easy. Prompt measures for maintaining the supply of salmon will insure a permanent and improving fishery.

AUTHOR'S LETTER OF TRANSMITTAL.

U. S. COMMISSION OF FISH AND FISHERIES,
Washington, D. C., January 21, 1890.

Col. MARSHALL MCDONALD,
U. S. Commissioner of Fish and Fisheries,

SIR: In accordance with instructions received from you June 3, 1889, directing me to make an investigation of the salmon rivers of Alaska, with particular reference to the habits, abundance, and distribution of the salmon, the conditions and methods of the fisheries, and the steps necessary to prevent their decline and to render them permanently successful, I left Washington June 10, 1889, in company with Mr. Robert E. Lewis, who was detailed to assist me in the exploration. We arrived in San Francisco June 18.

Finding that Capt. E. P. Herendeen, whose services had been secured as surveyor for the party, could not go with us, Mr. Franklin Booth, of the University of California, was engaged to take his place.

We were delayed in San Francisco, awaiting an opportunity to sail, until July 3, in the mean time purchasing materials necessary for the expedition. Prof. George Davidson, of the U. S. Coast and Geodetic Survey, obtained from the General Office of the Survey permission for us to use various instruments belonging to his office, including a theodolite, a level, a barometer, and other articles mentioned in the surveyor's report.

On July 3 we sailed from San Francisco for Port Townsend, where we arrived July 6. We were joined here by Mr. Livingston Stone, who was detailed by you to inquire especially into the feasibility of fish culture in Alaska.

The Karluk Packing Company's steamer *Karluk*, of San Francisco, was to convey us from here to Kadiak, but we were detained by an accident to her keel and did not sail from Port Townsend until July 19.

We reached St. Paul, Kadiak, July 28, and Karluk August 2.

We found that, owing to the lateness of the season, it was impossible to carry out the programme indicated in your letter of instructions. There was no opportunity of reaching Bristol Bay, and only one vessel departed from Karluk for Cook's Inlet. This was the steamer *Francis Cutting*, which sailed August 7, only five days after our arrival at Karluk, and we learned that she would not return in time for us to accomplish anything at that place during the fishing season.

Finding that Karluk is the most important salmon fishing station in Alaska, yielding fully one-half of the entire catch of the Territory, I concluded that we must begin our studies there, even if it became necessary also to limit them to that locality.

There is practically no communication in Alaska except by water. There are no lines of vessels running regularly from place to place, and whenever it is desirable to cover an extended field of investigation it is essential to provide a vessel to carry the party to the places to be investigated.

On August 15 we left Karluk for a trip to Karluk Lake, to examine the spawning grounds of the red salmon. We could not go up the river because of the low stage of the water, the extreme difficulty of walking along the shores, and the impossibility of taking boats through the rapids, which are several miles in extent. We sailed therefore around into Uyak Bay, and pushed up to the head of one of its arms, from which we made a portage of several miles to Karluk River above the rapids. The journey to the lake was completed August 17, and we remained there until the 21st. On the return to Karluk there was some delay on account of a storm, so that we did not arrive until August 27.

The party sailed September 7 for Alitak Bay, where we remained inquiring into the history of the fishing until the 11th, on which date we departed in the steamer *Haytien Republic* for San Francisco. We reached San Francisco September 21. From here Mr. Stone returned to his station at Clackamas, and Mr. Booth to his duties in the University of California. Mr. Lewis and I arrived in Washington October 13.

We were greatly assisted in our investigations by the Alaska Commercial Company, of San Francisco, and their agents on the island of Kodiak; also by the Karluk Packing Company, whose office at Karluk was our headquarters while at that station. Capt. L. P. Larsen, of the Arctic Packing Company, gave us every possible facility in his vessels and at the canneries of the company. The Kodiak Packing Company assisted us materially in our exploration of Alitak Bay. Messrs. Ford and Stokes, of the Russian American Packing Company, and Mr. Blodgett, of the Royal Packing Company, rendered material aid to Messrs. Booth and Stone during their visit to Afognak.

Mr. Booth has prepared a report upon his work, and also sketches and charts of the regions investigated. In this he was assisted by Mr. Lewis. Mr. Stone's report on the possibilities of fish culture is separately transmitted. Keeping in mind your instructions to devote my time chiefly to the salmon, I did not make large collections of other fishes, and have reserved their discussion for a future occasion. More than fifty photographs were made, to illustrate the physical features of the region and the methods of the fishery.

In conclusion, I wish to suggest the desirability of beginning investigations of this nature earlier in the year and continuing them later. The life history of our Pacific salmon is very imperfectly known, and it is difficult to make practical deductions from the insufficient data in our possession.

Very respectfully,

TARLETON H. BEAN,
Ichthyologist.

COPY OF ORDERS.

U. S. COMMISSION OF FISH AND FISHERIES,
Washington, D. C., June 3, 1889.

Dr. TARLETON H. BEAN,
Ichthyologist, U. S. Fish Commission:

DEAR SIR: You are hereby charged with the investigation, during the summer of 1889, of the salmon rivers of Alaska, authorized by the following act of Congress, approved March 2, 1889:

> That the Commissioner of Fish and Fisheries is hereby empowered and directed to institute an investigation into the habits, abundance, and distribution of the salmon of Alaska, as well as the present conditions and methods of the fisheries, with a view of recommending to Congress such additional legislation as may be necessary to prevent the impairment or exhaustion of these valuable fisheries, and placing them under regular and permanent conditions of production.

Your party will consist, besides yourself, of the following-named persons: Mr. Livingston Stone, Capt. E. P. Herendeen, and Mr. Robert Lewis.

Instructions for the conduct of the work are herewith inclosed. You will arrange to leave San Francisco at the earliest date possible, and will proceed directly to the island of Kadiak, where your explorations will begin.

As you will have only a comparatively short season during which to carry on these investigations, it will be necessary to limit your operations to a few regions, of which Kadiak Island (Plate LXXX), Afognak Island (Plate LXXX), Cook's Inlet, and Bristol Bay are the most important. They should be visited in the order named, unless, after your arrival at Kadiak, you should find that the salmon fishery interests of Bristol Bay have greater need of attention than those of Cook's Inlet, in which case the Bristol Bay region should be taken in hand next after Kadiak and Afognak. This is, however, on the supposition that you will not have the time to visit all of the regions.

You will pay most attention to those rivers in the districts mentioned where the fishery is now being prosecuted with the greatest activity, and also those which, from their location and the abundance of salmon, are likely to attract the canning interests at an early day. Upon your arrival at St. Paul, Kadiak, you will probably obtain the information necessary to enable you to map out the course of your explorations.

It is on the short rivers, and especially those on Kadiak and Afognak islands, as well as those on the adjacent coast of the peninsula, that the greatest fishery abuses are said to exist, and the dangers from injudicious fishing are most imminent. This class of rivers should, therefore, be carefully studied; and you will also seek to locate all the prominent salmon rivers in each district, ascertaining their chief characteristics, even though you may be able to do this, in many cases, in only a superficial way.

Your observations should all be made with a view to their bearing upon the practical question, as to how the salmon interests can best be protected, and to presenting to Congress a clear and succinct report upon the entire subject.

Three subjects are presented by the investigations in question, namely: First, the natural history of the salmon and the physical characteristics of their environment, in connection with which the river fishes generally may be studied. Second, the conditions, methods, and statistics of the salmon fisheries. Third, the artificial propagation of the salmon in Alaskan rivers.

Mr. Stone has been detailed to accompany you on account of his extensive knowledge respecting salmon culture on the Pacific coast. He should be given special charge of that branch of the work, but he will undoubtedly be able to assist you in the other subjects. Otherwise you will apportion the work among your assistants in such manner as seems best.

The duration of your stay in Alaska will be determined by the length of the season suitable for field investigations. A letter has been addressed to the Alaska Commercial Company, requesting them to furnish you and your party with transportation to and from Alaska, and to grant you the customary facilities at their stations. You will call at the office of the company immediately upon your arrival in San Francisco, and ascertain what arrangements can be made with them.

Should the opportunities occur for sending mail home, you will inform me, from time to time, of the progress of your work.

Very respectfully,

M. McDonald,
Commissioner.

INVESTIGATION OF THE SALMON AND SALMON RIVERS OF ALASKA.

PHYSICAL CHARACTERISTICS OF THE ENVIRONMENT OF THE SALMON.

KARLUK BAY.

(Plates XLV and L-LIX.)

The marine life of the Alaskan salmon is entirely unknown except when the various species approach the mouths of certain rivers to ascend to their spawning grounds. We do not know whether the ocean currents influence the movements of the schools of salmon, and we are not acquainted with the capacity of the salmon for enduring variations of temperature at sea. It appears from the best information we can obtain that the schools of salmon have not been observed at a greater distance than a mile and a half off-shore. The direction of their ocean movements has not been determined, but Mr. Hirsch informs us that in approaching Karluk they come from all directions and continue in compact schools until they are close to land, when the schools break up. It is assumed as an established fact that the great body of the salmon come up from the sea at a certain time of the year and ascend streams for the purpose of reproduction. We know that at the time when the salmon approach the Alaskan shores certain species of small fishes constituting their food are abundant at sea near the land. Among these are the capelin, herring, and lant. Salmon continue to feed upon these species until they are ready to forsake the sea and enter the fresh waters.

We could not learn that variations in temperature had much effect upon the daily catch of salmon. The lowest temperature of the water noted at the surface in Karluk Bay during our visit was 50°, and the highest 60°, the latter observed at noon, August 12. The greatest variation in temperature observed in any one day occurred August 13. At 7 a. m. the surface water was 50° and at noon it had reached 59°. The ordinary variation from 7 in the morning to 6 in the evening was from $2\frac{1}{2}$ to $4\frac{1}{2}$ degrees.

One of the sources of safety for the salmon at Karluk is the presence of beds of the bull kelp, *Macrocystis giganteus*, in which the fish find shelter from the seiners.

Karluk Bay is merely a shallow arm of Shellikoff Strait, limited on the southwest by Cape Karluk, or Karluk Head, and on the northeast by high bluffs at the head of Karluk Spit. The outlook from Karluk Bay is towards the northwest. The beach descends very gradually from a low spit, and is composed of coarse gravel and large granite bowlders. The bottom slopes down gradually until, at a distance of 100 fathoms from the shore, the depth is several fathoms. There is very little good holding-ground for vessels. Some of the firms have fixed moorings at which their vessels ride out

moderately severe storms in safety. A secondary indentation is found between Karluk Head and the mouth of Karluk River. This is a little cove with a fine gravelly beach and is frequently resorted to for seining salmon. The Karluk River empties into the bay at the point of the spit through a narrow and comparatively shallow mouth.

KARLUK SPIT.

(Plates LIV and LXXXI.)

The bay is separated from the Karluk River Valley by a low spit, which is about three-fourths of a mile long, about 100 yards wide at its extremity at ordinary high tides, and scarcely more than 30 yards wide at its head; its average width is about 60 yards. Its ocean beach has already been described. The river beach in its lower half is lined with moderately large bowlders, while the upper half contains finer gravel and deposits of river ooze. The elevation is so slight that in severe storms the sea washes over it into the river, flooding some of the buildings of the canning companies. There is a thin soil along the ridge of the spit which is utilized by some of the workmen for small vegetable gardens. The upper end of the spit not occupied by buildings is covered with a heavy growth of grass and weeds. Mr. Booth describes the formation of this little peninsula in the following words: "The spit is formed of loose granite gravel, washed into its present position by storms and tides from the bases of the high granite cliffs which make the coast-line of this part of Kadiak Island so prominent. These cliffs are constantly crumbling under the combined action of air, water, and frost, and the talus thus formed is constantly being added to the spit, gradually making it wider and longer. As the strongest prevailing gales come from the northeast, the débris is carried southwest to the further end of the spit, which accounts for the present position of the river mouth and the difference in width of the spit.

"There is hardly any doubt that the present lagoon was at one time the estuary of the river, then a far more powerful stream than at present and capable of carrying out to sea the débris carried across its mouth. As the river dwindled in size and volume the spit gradually encroached across its mouth, crowding it southwest along the base of the cliff until its mouth reached the present location.

"The granite cliffs, whose fragments have formed the spit, extend from Karluk Head, a bold headland about one-half mile southwest of the river mouth to the southwestern shore of Uyak Bay, and rise almost perpendicularly to a height of from 1,500 to 2,000 feet. The first rise of the peak, called on the Coast Survey [charts] Cape Karluk, I determined by transit observation to be about 1,600 feet high.

"This peculiar shape of mouth is not confined to the Karluk River alone. The Sturgeon and Little Rivers, distant respectively 4 miles southwest and about 30 miles northeast of Karluk, have similarly shaped mouths, and in each can be seen the outlines of their old estuaries.

"The ordinary tides on the beach at Karluk range from 12 to 18 feet, and in the river from 3 to 5 feet. The tide reaches up the lagoon or old estuary shown on the accompanying charts as far as the lower rapids, where the river and lagoon unite. The river here is about 300 feet wide, the whole width of its bed being filled with bowlders; in summer the water is too shallow for a bidarka to pass. The velocity of the current here is about $1\frac{3}{4}$ miles per hour."

KARLUK RIVER.

(Plates LX–LXII, LXVIII–LXIX, and LXXXI.)

For reasons elsewhere mentioned we did not follow the entire course of this river; the surveys of Mr. Booth, however, developed the fact that the lower portion of the river bed is much wider than is indicated on the charts furnished us at the outset of our expedition, and the relative widths of the river at its source and Karluk Lake, whose waters it carries off, show a very much greater difference than the maps represent. The direction of the Karluk in the first 5 miles of its length is a little west of north, this portion of the river ending at the portage to the west arm of Uyak Bay. From this portage it pursues a northwesterly direction for a short distance, and the general direction of the remainder of its bed is westerly. According to a manuscript chart prepared in 1867 by Archimandritoff, the mouth of the Karluk is in latitude 57° 34′ 30″ N., and longitude 154° 21′ 20″ W.

Mr. Booth's notes on the river are as follows:

"Karluk River leaves Karluk Lake at its northwest extremity as a shallow stream, about 130 feet wide, with a depth of about 12 inches at the summer stage, and flowing between low banks, from which rise on the western side the range of mountains which borders the lake. It soon leaves these, however, and wanders in a sinuous course, full of sloughs and lagoons, across its wide valley. In its windings it frequently attains a width of 600 feet, with a correspondingly diminished depth. It was a matter of great difficulty to find a place deep enough to float a bidarka. As we traveled farther down the river became narrower and the current more rapid, while places were passed in which the water was 6 feet deep. Near the isolated mountain shown on the chart the river cuts through a bed of ferruginous clay, which it has washed out so as to make an 8-foot channel alternately along the eastern and western banks. This clay bed is worthy of mention as being the only one found by us on the island. After passing the mountain the rate of descent measurably increases. Here we judged by the barometer that the river is about 200 feet above tide water at Uyak Bay.

"The distance in a direct line from the point where Karluk River leaves the lake to its mouth at Karluk we estimated at 16½ miles.

"In the first 5 miles its slope is inappreciable except in the rapids a short distance north of the lake, where in a distance of about 500 yards the river falls about 10 feet. This would leave about 250 feet of descent in about 12 miles direct distance, giving as the slope of the river valley about 20 feet to the mile.

"As we did not travel along the river banks below the point where the barabara, called Nicolai's, is located at the portage to Uyak Bay, we could not determine the length of the river channel, nor hence its average rate of descent. From the generally winding character of the river I should place it at 10 feet to the mile.

"The Karluk appears to travel throughout the whole of its course along the bed of an ancient glacial terminal river, whose successive levels of subsidence can be most plainly seen on the sides of the mountains south of Karluk. Hence its bed and banks are composed of irregularly sized, water-worn slate bowlders, surrounded by the fine gravel of the same material, intermixed with sandstone and jasper.

"After leaving the lake it flows along this level valley, which varies from 1 to 3 miles in width, for a distance of about 6 miles. After this the valley, as far as we could see, is full of low, rolling hills. At its mouth, and for about 5 miles from the spit, its valley is narrow and closely hemmed in by the surrounding mountains. Throughout its course, except in the level and marshy portion, it flows between bluffs from 10 to 40 feet in height. In the lagoon, which was in former times its estuary, these bluffs are as much as 80 feet high and slope steeply to the water's edge.

"There is no timber on the river, and it was only with great difficulty that the natives of our party could find enough dry [shrubs] for cooking purposes at the portage. The low hills of the river valley are covered with tall grass and full of water holes and pitfalls. The level portion of the valley is almost entirely a quaking bog, covered with moss and occasional clumps of low shrubbery."

The shrubs for the most part consist of willows and alder, the willows reaching their greatest size—in fact attaining the size of small trees—along the banks of the small streams tributary to the Karluk. The alder forms dense thickets, which are almost impassable. At higher elevations the alder predominates. The heath family is represented by several species, producing edible berries in great abundance. Cranberries of small size abound in some of the bogs and extend to the tops of the hills at elevations of nearly 2,000 feet. Some species of *Rubus* are very common, and especially *R. chamæmorus*, known on the island of Kadiak as the Maleena. These are edible species and are eagerly sought after by the natives. Fire weed is one of the most characteristic of the common plants of the region, its pink flowers forming masses of color which contrast beautifully with the varied green of the shrubs and the monotonous straw-color of the wild wheat. Crane's bill and golden rod occur in profusion. Monk's hood, blue gentian, and violets are very common. Wild roses are even more abundant than in our own vicinity. Wild celery and wild parsnips are everywhere to be seen. In the river, in certain localities, there is a profuse growth of eel grass. *Sagittaria* and yellow water lilies abound in some parts of the river. The collection of plants, however, will be referred to in detail at another time.

"The surface of the numerous ponds [in the valley of the Karluk] is covered with a peculiar iridescent film characteristic of petroleum. An examination of this region would very probably reveal the existence of petroleum springs and possibly reservoirs. The prospect is certainly fair, for the strata of the whole region is evidently colored with bituminous matter, especially the sandstones. Just such strata are commonly found associated with beds of coal. Since my return I have made some experiments upon the coals of Cook's Inlet, which occur in strata exactly similar."

The Karluk receives no large tributaries, but is augmented by the waters of innumerable small creeks from both sides of its valley. None of the tributaries seen by us and reported by others who have traveled the entire length of the river exceed a width of 6 feet at the mouth. The canneries located on the spit obtain their water supply by damming up small streams behind the native village of Karluk and conveying the water in iron pipes from the reservoirs thus formed to the buildings. As these pipes are carried on the top of the ground, they are taken up in the winter to prevent freezing.

KARLUK LAKE.

(Plates LXIII–LXVII and LXXXII.)

As already stated Karluk River rises in Karluk Lake. This lake is about 8 miles long and has an average width of probably 2 miles. Its general direction is north and south. The maximum depth of the lake is unknown. I tried a sounding, with 27 fathoms of line, about 500 yards from the shore, and found no bottom. The water is blue. Along many portions of the shore the lake is very shoal for a considerable distance from land. In other places there is deep water close to the margin. The shores are composed of bowlders of various sizes, consisting of granite and other rocks. Sand beaches are entirely absent as far as our observations extended. No aquatic plants were observed around the margin of the lake. The shores are covered with a greasy deposit, doubtless composed of decayed animal matter, and in the very shoal water in many places there is a dense growth of dirty looking confervæ. There is a luxuriant growth of grass throughout the basin of Karluk Lake, extending often to the tops of the mountains. Willows exist here as good-sized shrubs, and in some places as small trees. The low grounds in many portions of the basin are covered with cottonwood trees, some of which attain to a height of 60 feet and a trunk diameter of 18 inches.

Conspicuous among the fruit-bearing plants is a species of elderberry, *Sambucus*, bearing brilliant red berries, which form part of the food of the bear. In the cottonwoods are numerous families of the American eagle, and the shores of the lake harbor many species of birds, among which are gulls and terns, plovers, and magpies. Ducks and loons are found on the lake. At about the middle of its length Karluk Lake divides into two arms; one, extending to the eastward, is referred to in this report and on Mr. Booth's charts as the east arm; the other follows the general direction of the lake, and is very much longer than the east arm. Three small islands are situated near the junction of the east and west arms. Karluk Lake receives the waters of numerous small streams, in which salmon and trout are found whenever they are not prevented from entering them by the abruptness of the ascent. Each of the arms of Karluk Lake is connected by a short, rapid, and crooked river with smaller tributary lakes. The lake tributary to the east arm is about four-fifths of a mile in length, and the one connecting with the west arm is about 1½ miles long. In the small tributaries of Karluk Lake the rivers connecting its arms with their tributary lakes and at various places around the shores of the principal lake—particularly at its southern end, between the mouths of rivers—we found nests of the red salmon. Karluk Lake is surrounded on all sides, except the north, by low mountains, some of the elevations of which exceed 2,000 feet.

During our stay, from the 18th to the 21st of August, the lowest temperature of the water of the lake was 48½°; this was at 4.30 a. m. The highest recorded temperature of the water was 55° at 9.30 a. m. August 20. The highest temperature of the air was observed at 10.20 a. m. August 20, when it was 77°, and the lowest temperature during our visit occurred at 4.30 a. m. August 21, when it dropped to 30½°, ice being formed at our camp. Although the air was intensely cold, the surface water of the lake registered 48½°. The small rivers connecting Karluk Lake with its tributary lakes contain no obstructions to the passage of the salmon. These lakes

freeze over in winter, and the natives travel over them to attend to their traps. They claim that they can obtain salmon at any time during the winter through the ice.

The mouth of Karluk River is out of all proportion to the importance of the industry located near it. Its width at low water is less than 100 feet, and its depth is so slight that steam launches drawing only 3½ or 4 feet often find it impossible to enter. It flows parallel to the direction of the beach almost the entire length of the spit before it passes into the sea. When it turns to the eastward it widens out into a shallow lagoon nearly 2 miles long and about a half mile wide. Beyond this lagoon it contracts within its shallow narrow limits and flows over a long series of rapids. The tide rises in the river from 3 to 5 feet, and its influence is felt throughout the lagoon. The fresh water begins practically at the rapids, about 2½ miles from the bay. During the time of our stay the water was so clear that salmon and trout could be seen on the bottom. During freshets, of course, large quantities of soil are brought down, making the water turbid, and numerous plants are rooted up and floated to sea by the current. The temperature of the water at Karluk and other localities, as recorded by Mr. Stone, varied as follows:

1889.	Karluk Bay.		Karluk River.	Air.	State of sky.
August 4:					
5 p. m.	52°	Tide coming in	53°	52.5°	Cloudy.
August 5:					
7 a. m.	52	Tide going out	52.5	52	Cloudy.
12 noon	52		55.5	57	
6 p. m.	52	Tide coming in	52	53	
August 6:					
7 a. m.	51	Tide coming in	53	51	Sunshine.*
12 noon	53		59	59	
6 p. m.	53.5		54	59	
August 7:					
7 a. m.	51.5	Nearly low tide	55	55	Sunshine.
12 noon	54.5	Tide ebbing	56.5	60	Do.
6 p. m.	54.5	Tide ebbing	58.5	62	Do.
August 8:					
7 a. m.	51.5	Tide ebbing	55.5	53	Sunshine.*
12 noon	54	High tide	56	60	Do.
6 p. m.	55	Low tide	60	62	Do.
August 9:					
7 a. m.	56.5	Very low tide	55	54	
12 noon	56	High tide	55	58	
6 p. m.	56	Low tide	60	60	
August 10:					
7 a. m.	51.5	Very low tide	57	54	
12 noon	54	High tide	54	54	
6 p. m.	54	Low tide	56	53.5	
August 11:					
7 a. m.	53	Low tide	53	52	
12 noon	54.5	High tide	53.5	62	
6 p. m	54	Low tide	55.5	60	
August 12:					
7 a. m.	52	Low tide	54.5	54	
12 noon *	60	Half flood	57	60	
6 p. m	53.5	Low tide	57.5	66	
August 13:					
7 a. m	50	Low tide	54	52	
12 noon	59	Half flood	57.5	66	
6 p. m.	51	Half ebb	53.5	56	
August 14:					
7 a. m.	51.5	Low tide	53.5	52	
12 noon	53		54	54	
6 p. m.	52.5	Half ebb	56	51.5	
August 15:					
7 a m.	51	Half ebb	52.5	52	

* These temperatures were taken on the beach. The air has been very warm this forenoon, and partly accounts for the high temperature of bay.

Karluk Lake.	Water.	Air.	Remarks.
August 18:	°	°	
7 a. m	50		
6 p. m	51.5		
August 19:			
7 a. m	50	47	
9 a. m		55	Cloudy.
6 p. m	54.5	53	
August 20:			
5.45 a. m. (sunrise)		36.5	
9.30 a. m	55	65	
10.30 a. m		77	The hottest yet on the island. A beautiful bright, warm, sunshiny day. At 5 a. m. Mr. Lewis found the temperature to be 35.5°.
August 21:			
4.30 a. m	48.5	30.5	A beautiful, faultless morning.
August 22 (Barabara, on Karluk River):			
6 a. m	48.5	50.5	

The foregoing temperatures were taken with thermometer 6801, which was left here by Mr. Stone. The temperatures which follow were taken with thermometer 6802

August 27, 6 p. m., Karluk Bay, 52°; Karluk River, 53.5°; air, 56°; fair. August 28, 7 a. m., Karluk Bay, 50°; Karluk River, 51.5°; air, 53°; cloudy; 12 noon, Karluk Bay, 51°; Karluk River, 51°; air, 54°; cloudy; 6 p. m., Karluk Bay, 50.5; Karluk River, 50.5°; cloudy. August 29, 7 a. m., Karluk Bay, 50.5°; Karluk River, 48°; air, 52°; fair. August 30, Afognak, very stormy and windy; 6 p. m., bay, 49.5°; air, 49.5°. August 31, Afognak, rain-storm; 7 a. m., bay, 54.5°; 12 noon, bay, 49.5°; air, 52°; 6 p. m., bay, 49.5°; 8 p. m., air, 47.°. September 1, Afognak, clear; 7 a. m., bay, 47.5°; air, 47.5°; noon, bay, 56°, air, 60°; 6 p. m., bay, 51.5°, air, 53°. Litnik River, 10 a. m., bay, 47.5°; village, 49.5°; dam, 50°; clear. September 2, Afognak, 7 a. m., bay, 49.5°; air, 47°; clear; noon, bay, 53°; air, 58°; cloudy; 6 p. m., bay, 52°; air, 53°; cloudy. September 3, Uyak Bay, on steamer *Aleut*, 6 p. m., air, 47.5°; rainy; 9 p. m., air, 45°; rainy. September 4, Uyak Bay, on steamer *Aleut*, 7 a. m., air, 46°; fair; noon, air, 51°; fair; 6 p. m., air, 50°; fair. September 5, 7 a. m., Karluk Bay, 47°; Karluk River, 46°; air, 43°.

Annual rain-fall at St. Paul, Kadiak.

	Inches.
1885	65.70
1886	54.25
1887	61.06
1888	64.96
	245.97
Average	61.49

In December and January the rain-fall is usually greatest. In September it is pretty heavy. Snow comes down on the west side of the mountains in summer to within about 500 feet of the sea-level.

During the time of our stay at Karluk there were no obstructions, either natural or artificial, to the ascent of the salmon in the river, unless we may regard the low summer stage of the water in such a light. There were remains of some traps of wire netting which had been placed in the river by certain parties, but these traps did not remain long in the water before they were destroyed by some of the fishermen. In former years there have been impassable barriers to the ascent of the fish, but these were removed before the date of our exploration. It is certain that the seining operations, carried on almost without interruption, except during twenty-four hours in the week, prevent many salmon from going up the stream for the purpose of spawning. The number of salmon actually caught in Karluk Bay, near the river mouth and in the lower portion of the river, is so large as to make a true statement concerning them seem incredible. In 1888 the canneries put up over 200,000 cases,

averaging about 13 red salmon to the case, or more than 2,500,000 fish. In 1889 the number of fish put up was still larger, reaching probably 250,000 cases, containing more than 3,000,000 salmon. As the number of fish arriving at Karluk Bay for a long period of years has been known to be far greater than in any of the other bays of southern Alaska, it is probable that most of these salmon were present at Karluk for the purpose of ascending the river to spawn. Now the number of spawning fish seen in the river, the lakes, and their connecting rivers was comparatively very small, indeed out of all proportion to the number taken on the beach.

We were told by persons who have spent a number of years at Karluk that in former years the great catch of salmon was made in the river, and that at a certain time in the spring myriads of young salmon filled the river on their way down to the sea. In my opinion this river will soon cease to show such a state of productiveness, if indeed it has not already done so, and we must conclude that the most formidable obstruction at present to the ascent of salmon in the Karluk for the purpose of reproduction is overfishing.

The river freezes over in winter with such solidity that the natives travel along its course all the way to Karluk Lake on the ice. As the water is very shoal in many places, it must necessarily freeze to the bottom in such localities. The natives told us, however, that salmon may be taken any time during the winter under the ice in deep holes in the river, as well as in Karluk Lake. Karluk River does not thaw out until late in the spring.

The relations of the rivers to one another could not be determined in the short space of time at our disposal.

The temperature of the air was recorded by Mr. Stone, and a table showing the results of his thermometer readings is given elsewhere.

There is no doubt that the salmon are affected in their movements by the condition of the weather, but observations upon this subject have been so fragmentary that no principles as yet can be deduced from them. For some reason unknown to us the salmon were late in making their appearance at Karluk in 1889. Up to the first of August the outlook for the fishermen was very discouraging, but during the month of August the arrivals of fish were numerous and the schools very large.

Photographs were taken to show the relations of the seining beach to the lower course of the river, and especially the spit with the buildings located upon it, the nature of the banks and adjacent mountain slopes near its mouth, and also a series of Karluk Lake and its tributaries.

ALITAK BAY AND OLGA BAY.

(Plates LXXII–LXXVI and LXXXIV–LXXXV.)

The outlines of this large and irregularly shaped body of water as laid down upon the chart furnished for our guidance differ greatly from those represented upon the running chart of Capt. L. P. Larsen, which Mr. Booth was allowed to copy for the use of the U. S. Fish Commission. About 10 miles to the northward of Cape Alitak the bay contracts abruptly, and continues narrowing to the north for a distance of about 7 miles, when it expands again into a great bay fully 15 miles in length, composed of two enlarged ends connected by a narrower intervening body. This upper portion has been called Olga Bay, and it is the body of water in which we are most interested at

present, because some of its tributaries furnish all of the red salmon now shipped from Alitak Bay. The general direction of Olga Bay is nearly northeast and southwest.

The chief salmon river or creek falling into Olga Bay is "at the outlet of the second chain of lakes into the upper portion of Olga Bay, a point only about 2½ miles from the southwestern shore of the island, Olga Bay itself being separated from the ocean only by a narrow neck of marshy land about three-fourths of a mile across."

"At this river the Arctic Packing Company's cannery is located. The detour required to reach it by steamer is upwards of 30 miles longer than it would be if Olga Bay were connected with the ocean at its western end."—(F. BOOTH.)

The width of this stream at the time of our visit, September 8, was scarcely more than 10 feet near its mouth, and the depth of the water was 8 inches. The river is plotted by Captain Larsen as 1 mile in length. At its head is a chain of two large deep lakes, 4 miles long. At the river mouth the bottom is lined with coarse pebbles similar in size to those composing the adjacent beach. The exit of this stream is often changed by storms. Young salmon, about 2 inches in length, were plentiful here. The fishing is done with sweep seines in the bay near the river mouth and was about closed September 8. Red salmon is the principal species, but a few silver salmon run into it also.

On the shore of Olga Bay opposite the cannery of the Arctic Packing Company there is a small fishing station operated by the Kodiak Packing Company, and known as the White Star Fishing Station. Red salmon and silver salmon are found there.

At the northeastern end of Olga Bay there is a fishing station used by the Kodiak Packing Company and called by them the North Fishing Station. This locality was seen September 9 by Mr. Booth, who describes it in the following words:

"The river at the North Fishing Station spreads out at its mouth into two shallow lagoons, which once formed estuaries for a large river in the present bed. These lagoons are separated from the bay by a long, narrow spit of slate gravel, overgrown with rank grass, through which the river, or rather creek, has an outlet about 30 feet wide and 12 inches deep. This creek takes the drainage from a narrow valley running north amongst a series of very barren, snow-covered mountains. The shores of the lagoons are covered with occasional patches of alder, thicker on the western than on the eastern side. The lagoons themselves are each about 500 yards long and 300 yards wide, and at low water must be almost dry. The company had ceased fishing there at the date of my visit, so we staid but a short time, not sufficient to allow me to attempt any extended reconnaissance."

In the vicinity of the North Fishing Station there is a small belt of timber, consisting chiefly of alder and cottonwood. I was informed that 30 cords of wood suitable for fuel were cut during the fishing season at this locality. Not far away from this station to the westward is a region which is noted for the number of its bears.

The waters of Olga Bay and Alitak Bay at the time of our excursion were teeming with jelly fishes, and in Alitak Bay I observed a number of small whales. The narrows connecting Alitak Bay with Olga Bay receives many small stream on both sides, and several native villages are located at the mouths of these streams. Numerous humpback salmon are found in all of them. At and near the Kodiak Packing Company's cannery, in Snug Harbor, two small creeks fall into the bay, both of which were full of spawning humpback salmon.

The following subjects were photographed in Alitak Bay:

The Kodiak Packing Company's cannery and the fleet in the harbor; Alitak Narrows from Snug Harbor and from the north end; the entrance to Olga Bay and the mountains of Olga Bay; the Salmon River near the Arctic Packing Company's cannery; a salmon creek; a group of natives; and a view looking out of Snug Harbor.

UYAK BAY.

(Plates LXX-LXXI and LXXXIII.)

Although a large and beautiful body of water, affording some fine harbors for the vessels of the salmon fleet, to which they run for shelter from the severe storms that drive them away from the open roadstead of Karluk, Uyak Bay has no streams containing salmon which are at present commercially valuable except humpbacks. A cannery belonging to the Arctic Packing Company is located in a cove forming part of the west arm of this bay. Its supply of fish, however, is obtained from Karluk, 17½ miles distant. Numerous streams of small size empty into the bay from the surrounding mountains. Some of these make their exit into Uyak Bay over an elevation which prevents the salmon from entering their mouths, but there are many streams abounding in humpback salmon, which in the middle of August were spawning or spent. Certain portions of the shores are suitable for seining, other portions are made up of bowlders and sharp stones, many of them incrusted with barnacles, which make it difficult to haul the seine. Alder, cottonwood, and several species of willows are found on these shores, and particularly around the portion called Larsen's Bay or Cove.

Flowering plants and ferns occur also in great profusion.

Around the wharves of the Arctic Packing Company cod, tomcod, herring, and other fishes were very abundant, attracted by the refuse from the salmon splitting-tables.

Across the mountain from the Arctic Packing Company's cannery, a lake is found which is full of fish, probably dolly varden trout, according to the testimony of Mr. Holmes.

One of the most famous of the humpback salmon streams of this bay is the one known as Alexander's Creek, upon which Mr. Booth has made the following notes:

"Directly south of and opposite to the Arctic Packing Company's cannery, in Larsen's Cove, Uyak Bay, is a small creek which at the time of our visit was said to contain more *gorbuscha* than any other known salmon stream in Alaska. This creek is a very short and narrow stream, rising in the high hills on the southern side of the bay and plunging down for about a mile over a very steep slate bed until it reaches the low land on the shores, where it widens out to about 25 feet wide, about a hundred yards from the beach. There was barely enough water to allow the *gorbuscha* to swim, especially at low tide, when, owing to the very gradually sloping beach and great rise and fall of the tides, the creek separates into several channels. At low tide the sea recedes about 300 yards. Its average rise and fall is about 18 feet.

"Several other small creeks empty into Larsen's Bay on its northern side, but owing to the high black slate bluffs, which almost everywhere line the shore, no fish can enter them."

Near the Arctic Packing Company's cannery, at Larsen's Bay, Mr. Booth describes "a large tract which apparently consists wholly of peat to a considerable depth. Above it is a small pond from which the cannery draws a portion of its water supply, the other portion being taken from springs which rise through the peat bog. At one of these springs an excavation 6 feet in depth did not reach the bottom of the peat deposit. Such deposits exist also in many places in the Karluk River Valley, and probably in the Sturgeon River Valley and others of similar topographical features. They may be a valuable source of fuel supply in the future if suitable means for drying the peat could be devised. As yet no attempt has been made to utilize them nor has any of this peat been experimented with so far as my information goes."

Photographs were made of the salmon fleet anchored in Uyak Bay during a southwest gale, of the harbor near the mouth of this bay looking across Shelikoff Strait and also to the northeast, besides Larsen's Bay, including the canning establishment of the Arctic Packing Company.

AFOGNAK BAY.

(Plates LXXIX and LXXXVI.)

After having completed preparations for a trip to Afognak Island, to make collections and photographs and continue our study of the salmon, Mr. Lewis and I were poisoned by a plant which we supposed to be wild celery and had to remain at Karluk. Mr. Booth and Mr. Stone accordingly made the excursion and investigated the physical characteristics of Afognak Bay, lake, and river, and the possibilities of conducting a salmon-hatching establishment in that region. Mr. Booth's account is given below. Mr. Stone's report will be referred to elsewhere:

"The interior of Afognak Island is, from the best accounts, made up of flat marshy valleys separated by mountain chains from 1,500 to 2,000 feet high. These valleys contain many lakes, which connect by means of short rivers and shallow estuaries with deep narrow inlets leading to the open sea. The most important of these is the Afognak River, and in Afognak Bay, the inlet at the mouth of its estuary, are situated the canneries of the Royal and Russian American Packing Companies. This river is but short, its total length measured from the point where it leaves the lake to the upper end of Afognak Bay being not more than 3 miles.

"As the whole of Afognak Lake can be seen from the source of the river, and our time was limited, it was not explored. Its extreme length does not exceed 3 miles, and its greatest width is about three-fourths of a mile. The general configuration is shown on the accompanying chart. It derives its water supply from small streams coming directly down from the surrounding hills and creeks, which drain two wide valleys to the northward. The lake seems to be surrounded by a thick fringe of spruce woods, except at its extreme north end, which is grass-covered, with here and there clumps of alder. Where the river leaves the lake it is about 130 feet wide, but narrows down to 70 feet in width in the course of 100 yards, and after going about one-third of a mile narrows still more, being there not more than 40 feet wide. Thus far it keeps an almost straight course, so much so as to remind one of a canal. From here on it winds about in long curves until it reaches a water-fall about 2 miles below the lake. Here the river crosses either a dike or a bed of very hard sandstone (the rock is much decomposed so that it is hard to tell its original character), falling about 20 feet in a series of cascades about 70 feet long.

"From the 'water-fall' the river flows on for about 100 yards at a much steeper grade than at any point above the falls, until it reaches an old Russian timber *zapor* about 6 feet in height, over and through which it falls, to continue 500 yards further in its steep channel until it reaches tide level and spreads out over its wide and shallow estuary. This estuary ranges from 100 to 400 feet in width, and at low tide is almost bare. Its length is about five-eighths of a mile. Near its mouth the river has again cut through a bed of hard rock, and the channel is narrowed down to about 50 feet and scoured out chiefly by tidal action to a depth of about 4 feet. Another ledge, apparently not so hard as the last-mentioned one, crops out about one-fourth of a mile below the *zapor*. In the upper end of Afognak Bay, around the mouth of the estuary, the bottom is covered with an exceedingly rank growth of the narrow flat-leaved eel grass; so thick is the growth of this grass that it is very difficult to push a boat even in 3 feet of water if the tide is low.

"At the time of our visit, in the latter days of August, the stage of the water in the river was exceedingly low. In the river proper there was no part of the channel where more than 18 inches of water covered the bed, and 12 inches would be fully the average depth, while places were found where the water was not more than 4 inches deep. Yet the river was well filled with *gorbuscha*. The bottom of the river is made up of material greatly similar to that in the bed of the Karluk River, slate, jasper, and quartz gravel predominating, interspersed with bowlders similarly composed of all conceivable sizes and shapes. The cross-section of the bed is uniformly level, but filled with holes the bottoms of which were composed of gravel about egg-size usually, but sometimes contained stones of 3 or 4 pounds weight. The *gorbuscha* were thickest in the neighborhood of these holes, but on examining the holes we found very few eggs under the gravel. Scarcely any finely divided slate was found in the river bed, although the banks were largely made up of this material. Although the river was so shallow at the time of our visit, Mr. Stokes, of the Russian American Packing Company, told us that in March last he was unable on account of the depth of the water to wade it in a pair of high rubber boots. This would make its depth over 3 feet.

"The river flows for almost its whole length through a valley, about 2 miles wide near the lake, gradually narrowing to about one-half mile at the head of Afognak Bay. This valley is filled with low mound-like hills, covered with a thick growth of the spruce peculiar to this portion of Alaska. Between these hills are gullies with small streams, almost completely hidden by the dense growth of sphagnum winding about in them. These woods are usually well supplied with salmon berries, blueberries, and huckleberries, so much so as to be noted for this throughout Alaska. The shores of the river are either flat or gently sloping, being composed of finely-divided slate gravel, which does not admit of very steep banks. Without doubt the present river valley, in common with that of the Karluk and other rivers of this region, was the channel of an ancient glacier, the traces of which are masked under the present abundant growth of bushes and tall grass, leaving nothing but the general configuration of the country to betray their former existence. Near the bay the shores of the estuary assume the form of low bluffs, similar to those at Karluk, but not so high. The mountains immediately surrounding the lake are more rounded in outline than those surrounding Karluk Lake, and at the time we saw them showed no snow-caps, although the mountains separating the two valleys at the northern end of the lake still carried

snow on their summits. As near as we could judge, they were about the same in height as the Karluk Lake range—from 1,500 to 2,000 feet.

"The grade of the river above the falls is very slight—not more than 7 or 8 feet to the mile. From the falls to tide-water the grade is much steeper, there being a difference of elevation, including the fall, of about 40 feet between the river above the falls and high-tide level in the estuary, which is at a distance of about 600 yards below the falls. The difference of elevation of the upper and lower ends of the estuary, calling the lower end of the estuary the head of Afognak Bay, is about 14 feet, that being the average rise and fall of the tide, which generally ebbs to the upper end of the bay, leaving the estuary almost bare. Great numbers of salmon are thus stranded and many die before the next tide rescues them.

"The Afognak River has two tributaries, both of which enter the main stream below the falls, in the position shown on the chart. Owing to the lack of time we did not trace them to their sources. Where they join the river they were from 15 to 20 feet wide and from 12 to 18 inches deep, with a current of about 2 miles per hour. Their shores, surroundings, and rate of descent are similar to those of the main river. At the time of our visit *gorbuscha* were running up them in great numbers.

"In the upper part of Afognak Bay, near the mouth of the estuary, are a number of small, low islands, the largest of which is the highest, its southern end rising in a high slate bluff 70 feet above high water. The slate here, as on the main island of Afognak, dips northwest at an angle of 20 degrees. This island, like the opposite shores on both sides of the bay, is covered with the peculiar species of spruce before mentioned. The strata of the bay shores attract attention by their sharply upturned edges, which cut the boot when walking over them. They consist of highly inclined bituminous shales and sandstones, interstratified with thin beds of yellow sandstone, which are apparently devoid of bituminous matter.

"Across the bay from the canneries in a northerly direction is a small cove running northwesterly about 700 yards. It forms a good anchorage, and is frequently so used. At its extreme end it receives the waters of a small creek, which emerges from the forest with a width of about 20 feet and a depth of 12 inches. Near its mouth it, like the main river and its tributaries, cuts through a bed of hard rock, which gives it a sharp turn. This bed may possibly be a continuation of that cut by the river.

"As regards obstructions, the *zapor* and fall, a sketch of the latter being appended, form the only important ones. The *zapor* is formed like an ordinary timber dam on its inside face. Its foundation consists of rough logs built crib fashion, on the top tier of which rests the spiling, formed of split spruce logs about 10 feet long, set at an inclination of about 30 degrees from perpendicular. This forms the inside wall of the dam, against which is piled gravel to stop up all holes. In its center is an inclined sluice about 3 feet square, opening upwards from the down-stream side, up which the fish run into the trap, a tank made of cribbed logs, about 6 feet square in interior dimensions. Here the fish are speared by the natives. This *zapor* is now going to ruin, many gaps existing in the spiling, which render the trap ineffectual. The fall, however, prevents many fish from ascending the river, as the series of cascades is difficult for them to surmount, owing to the shallow, rocky bed at their termination. If desired it would be an easy matter to construct a fish-ladder here, and obviate the difficulty completely.

"The river and creeks freeze over in winter, but we have no information as to whether the bay itself freezes or not. The silver salmon had just commenced running at the time of our visit. At the upper end of the bay, and along the east bank of the estuary, is an Aleut village of about 40 barabaras, called in the native language Litnik (meaning summer residence.) The natives are attracted here by the facilities for obtaining an abundant supply of salmon and berries for winter use. At the time of our visit nearly all of the barabaras were occupied."

The following temperatures were observed by Mr. Stone at Afognak:

Date.	Time.	Bay.	Air.	Weather.
		°	°	
Aug. 30	6 p. m.	49.5	49.5	Very stormy and windy.
Aug. 31	7 a. m.	54.5	....	Rain-storm.
Do	12 noon	49.5	52	
Do	6 p. m.	49.5	......	
Do	8 p. m.	....	47	
Sept. 1	7 a. m.	47.5	47.5	Clear.
Do	12 noon	56	60	
Do	6 p. m	51.5	53	
Sept. 2	7 a. m	49.5	47	Do.
Do	12 noon	53	58	Cloudy.
Do	7 p. m	52	53	Do.

Mr. Stone's record at Litnik River, September 1, follows:

Date.	Time.	Afognak Bay.	Village.	River dam.	Weather.
Sept 1	10 a. m	47.5°	49.5°	50°	Clear.

NATURAL HISTORY OF THE SALMON.

In Alaska the salmon family includes numerous species, most of which are represented by vast numbers of individuals. The sea teems with salmon, trout, and smelt, and the rivers and lakes are full of whitefish, grayling, and inconnu.

The largest salmon of the world are credited to this Territory, and there is no doubt that in Cook's Inlet King Salmon weighing over 100 pounds are occasionally taken, but this is far above the average weight of the species. The most abundant salmon in Alaska are the Red Salmon and the Little Humpback, and it is these species which figure in the wonderful tales concerning rivers which contain more fish than water, tales which sound incredible to those who have never visited Alaska, but which, however, in many cases are strictly true.

The salmon have been traced as far north as Hotham Inlet and one species is found well to the eastward of Point Barrow. It is quite probable that this species, the little humpback, extends its migration to the Mackenzie.

There are five species of whitefish in Alaska, one of which reaches a weight of over 30 pounds. This whitefish has formerly been confounded with the common one of the Great Lakes. It is the species known as Kennicott's whitefish, now proved to be identical with Richardson's.

The round whitefish, or the shad waiter of New England and the upper Great Lakes, extends through the Northwest Territory, and other parts of British Columbia, into Alaska, where it ranges far to the northward. Specimens have been obtained in the Putnam or Kuwuk River, a tributary of Hotham Inlet. This is a small fish, seldom exceeding 2 pounds in weight, but it is valuable as food and very abundant. An excellent species found still farther north is the *Coregonus laurettæ*, which has been obtained from the Bristol Bay region to Point Barrow. This is a little larger than the round whitefish, but does not much exceed 3 pounds in weight. It resembles our so-called lake herring. The other two species are less valuable than the three already mentioned, but the natives use them as food in great numbers and feed their dogs upon them also.

A fish resembling the whitefish, but very much larger, more elongate, and with a very strongly projecting lower jaw, which has given origin to the name shovel-jawed whitefish, is one of the best food-fishes of the Territory and grows very large. It is said to reach a weight of 50 pounds and a length of 5 feet. This is the Inconnu of the voyageurs or *Nelma* of the Russians. The *Nelma* is found in the Mackenzie and its tributaries, in the Yukon, and the Kuwuk. Doubtless the species occurs also in the Kuskoquim and the Nushagak.

The grayling, or blanket fish, is very abundant in the Territory, especially northward. Its range southward is not clearly known, but in the northern part of British America and from the Yukon north to the Kuwuk it is very abundant.

The smelt of Alaska are large and very plentiful. They resemble our eastern smelt in appearance. The range of the species is from the Bristol Bay region to Point Barrow, and they are most abundant from the early part of September until November. They abound in sheltered bays and tide creeks.

Still another smelt occurs around the shores of the Gulf of Alaska, which is identical with one of the California species, and a very excellent food-fish.

The capelin is found along all parts of the coast and is one of the most important food species of the cod and salmon.

Eulachon are very common in the Gulf of Alaska, particularly at Katmai on the peninsula of Alaska, where they have been salted and meet with ready sale.

The foregoing representatives of the salmon family have been reviewed simply to call attention to the wealth of the Territory in superior food-fishes. Their commercial importance up to the present time is small, but they will figure eventually and very prominently among the resources of Alaska. There is no doubt that many of the small marine species play a very important part in attracting the larger commercial species of the salmon family to certain localities.

Before proceeding to an account of the salmon and trout it may be well to state that the herring of Alaska is one of the finest species of its genus (*Clupea*), and is universally known as one of the fishes upon which the salmon subsist. The herring visits all parts of the coast of Alaska, running up into the bays in schools, sometimes covering an area of many square miles. It comes into the shallow waters of the bays to deposit its eggs, reaching Cook's Inlet for this purpose early in July, so that its appearance in force coincides with the height of the salmon runs. The capelin is also found early in the summer, and we know that salmon are very eager in their pursuit of this fish. The little sand launce, or lant, is also present in the bays in wriggling masses at the period when salmon abound.

The King Salmon (*Oncorhynchus chouicha*).

(Plate XLVI, fig. 1.)

The largest and finest of the Alaskan salmon is the King, or Chowichee, known also as the Takou, Columbia River, Chinook, and Quinnat. This valuable fish occurs in the large rivers as a rule, but we know that it runs into some of the small streams also, notably the Karluk, and some of the rivers emptying into the eastern part of Cook's Inlet. The Yukon and the Nushagak are the greatest King Salmon rivers. The species is found less abundantly in the Ugashik, Kuskoquim, and Kvichuk.

The King Salmon is the most favorably known of all the species; its average weight is above 20 pounds, and individuals of 100 pounds or more are recorded. At St. Paul, Kadiak, in 1880, Mr. B. G. McIntyre told me he had weighed one which registered 87½ pounds without its viscera; he believed the entire fish would have weighed 100 pounds.

The flesh of the King Salmon is paler in color than that of the Red Salmon, but superior to all others in flavor. The salted bellies are considered a great delicacy. The principal uses of this fish are as fresh fish and for canning purposes. In Alaska

has not yet acquired the importance belonging to it on the Columbia River, chiefly because of the distance from San Francisco to the Alaskan King Salmon rivers, and the difficulties of fishing in those waters.

This species is the first to arrive on the shores in the spring. It makes its appearance in southern Alaska in May, and Nelson found it in Norton Sound, the northern limit of its known migration, early in June. The time of its coming into Norton Sound corresponds with the breaking up and disappearance of the ice. Nelson observed that "the largest of these salmon run during the few days just preceding and following the breaking up of the ice, and thence on until the end of the season they decrease gradually in size and quality." In the Yukon the season lasts only about a month. Capt. L. P. Larsen informed me that the King Salmon is the first to appear in the Nushagak. Here the run is short, scarcely continuing into August. At the Karluk the species arrives late in May. Very few were seined there during the month of August. We saw stragglers on the 4th, 6th, and 27th of the month, and a few spawning fish were in the upper part of the river August 21. On the 4th of August a fine male of about 35 pounds, with the spermaries little developed, was seined on the beach. In its stomach I found forty-five capelin. Mr. Charles Hirsch states that the species is only an occasional visitor at Karluk.

The King Salmon continues to enter some of the rivers for the purpose of spawning until August. The height of the season, however, is reached by the middle of July in most localities. This fish travels up the rivers farther than any other species except the Red Salmon. In the Yukon it ascends far above Fort Yukon, more than 1,500 miles from the mouth of the river. Dr. George M. Dawson records its occurrence in the Lewes River as far as the lower end of Lake Marsh, where it was found in considerable numbers early in September. According to Indian authority it pushes on almost to the headwaters of the tributaries to the Lewes on the east side.

The King Salmon does not ascend rivers rapidly unless the spawning period is close at hand. It generally plays around for a few days, or even a couple of weeks, near the river limit of tide-water. After entering the fresh water to begin its journey to the headwaters of the stream it moves rapidly until it finds suitable gravelly bottom in clear water. No food is taken in fresh water. When a barrier to its ascent is met I am told that the fish charges at it repeatedly and persistently without regard to the consequences to itself. The nest-building habits have been so often described that it is unnecessary to repeat them here. The spawning takes place, as before remarked, near the headwaters of streams in clear shallow rapids. As far as we can learn, only those fish that ascend the streams short distances return to the ocean after spawning, and September is the month in which the spent fish go down to the sea. Turner mentions a female weighing 38 pounds, which had spawned and returned to the sea and was caught at Unalashka, September 25, 1878. This female was in fine condition for eating

There is no reason why the King Salmon should not return down the Karluk, as the distance is very short and the fatigue of the journey up-stream is very slight. There is ample testimony of a conclusive nature to the effect that after a King Salmon ascends 500 miles from the sea it never returns to it alive.

Mr. Charles Hirsch informed me that the Karluk natives watch for the King Salmon in May, and set up a great shout as soon as they discover it. Like the other species, it can be seen about 1½ miles off shore in great schools, but before coming

nearer the schools break up. There is no salt-water fishery for this salmon in Alaska, except along the beaches.

No falling off has been observed in the supply of the King Salmon; in fact the number used is very small in comparison with that of the Red Salmon.

The only destruction of King Salmon known to me was incidental to the efforts to prevent Red Salmon from ascending certain streams by an impassable fence, and this no longer exists.

The Dog Salmon (*Oncorhynchus keta*).

(Plate XLVI, fig. 2.)

This is one of the least important of the Alaskan salmon to Americans, but one of the most valuable to the natives. It is found chiefly in the small rivers and creeks, and is usually very abundant in all parts of the Territory as far north as Hotham Inlet, and probably Point Barrow. Its flesh is comparatively pale, and it deteriorates so rapidly in fresh water as to prove very unattractive to white people. The jaws become enlarged and distorted, and the flesh unpalatable.

In the rivers of California and British Columbia it is said to appear seldom or never in the spring, but in Alaska it makes its appearance on the coast in great schools about the middle of June and continues abundant for nearly a month, after which it decreases rapidly in numbers, disappearing usually about the time of the forming of the ice.

The average size of the Dog Salmon is about 12 pounds, but I have seen individuals that would weigh 20 pounds. On the 30th of August, at Karluk, a haul of a large seine yielded forty Dog Salmon and only one Red Salmon. Early in July the fish-drying frames of the natives on the shores of Cook's Inlet are red with the flesh of the drying Dog Salmon, or *Hyko*.

The natives cut off the head, split the fish in halves, and remove the back-bone, allowing the two halves to remain fastened at the tail. The sides are gashed at short intervals in order to facilitate the drying. The fur traders lay in a large stock of this dried salmon, which is known to the trade as *ukali*. In the fresh-run condition the flesh has a beautiful red color, resembling that of the Red Salmon, but not so brilliant.

In the small streams falling into Alitak Bay, with only a few exceptions, this fish and the Little Humpback are the principal salmon, and the natives dry them for winter use in large quantities. The Sturgeon River, according to Mr. Charles Hirsch, never contains anything but Dog Salmon and Humpbacks. In the Karluk the Dog Salmon is only an occasional visitor. At St. Paul, Kadiak, Mr. Washburn says that the *Hyko* arrives about July 1, and there is only one annual run.

Early in July the red color of the skin of the *Hyko*, or Dog Salmon, is somewhat remarkable in being interrupted at intervals along the sides, causing a sort of resemblance to bands.

The Silver Salmon (*Oncorhynchus kisutch*).

(Plate XLVI, fig. 3.)

The Silver Salmon is considered an excellent fish in the Puget Sound region, but is not so highly esteemed in the northern part of Alaska. It is used to some extent for canning, but is far less important for this purpose than the Red Salmon. It reaches a weight of about 30 pounds; the average weight in Alaska is less than 15

pounds. This species in Alaska, as in the Puget Sound region, is a fall-running fish. It does not ascend the streams to any great distance, and I have seen spent fish of this species coming down alive in the fall to within easy reach of salt water. Whether the species actually leaves the fresh water after spawning is uncertain. There is a conflict of observation on this subject.

Mr. John W. Clark, agent of the Alaska Commercial Company at Nushagak, a man who is noted for his veracity and intelligence, states that he has seen Silver Salmon come down the river alive in the spring. In some other Alaskan rivers Captain Lansburg, superintendent of the Thin Point Cannery, has seen only black and lank-looking salmon of this species during the winter.

At Afognak the species arrived August 5, 1889, but there was no extensive run until about the end of that month. A small Silver Salmon was seen at Karluk August 4. The species was not abundant there, however, until early in September, when about seven thousand were caught at one haul of a seine. It was about this time that one of Capt. L. P. Larsen's men at Karluk hooked a very large Silver Salmon, probably weighing over 30 pounds. This species is only an occasional visitor at Karluk. When it runs there it generally begins about the last of August, according to Mr. Charles Hirsch. Mr. Washburn informed me that it arrives at St. Paul late in August or in September, and that there is only one annual run. A few fish of this species are found in the small river in Olga Bay, near the cannery of the Arctic Packing Company. In the river at Thin Point, a small and very shallow, but constant, stream, both Silver and Red Salmon are found, the latter predominating. The season closes here early in September.

The Silver Salmon make their nests among the gravel and stones, from which they clean all dirt and slime. They use their snouts in collecting material for the nests, and Turner states that he has seen them with the snout worn off past the muzzle. After the spawning season, and during their stay in fresh water, they continue to be very much emaciated and in poor condition generally.

No decrease has been observed in the supply of this salmon as far as we are informed. Its late arrival in most localities limits the season during which it can be caught, and this serves as a sort of protection for the species.

The Humpback Salmon (*Oncorhynchus gorbuscha*).

(Plate XLVII, figs. 4 and 5.)

This is the smallest, the most abundant, and the most widely distributed of the Alaskan salmon. Its average weight is about 5 pounds, and individuals weighing 10 pounds are very uncommon.

The Humpback may be recognized readily by its excessively small scales, and, in the breeding season, by its greatly distorted jaws and enormous hump. This species is found in all parts of the Territory. Its range is known to extend several hundred miles to the eastward of Point Barrow, and probably includes the Mackenzie. Speaking of their extraordinary abundance, Turner has aptly remarked that "they appear at the surface of the water like the pin-drops of an April shower."

Mr. Charles Hirsch informed me recently that from about the 6th of July, 1880, there was in the Karluk River, continuing for five weeks, a glut of Humpback Salmon which kept all other salmon out of the river. It was impossible to pull a boat across

the stream, owing to the great quantities of salmon. A haul was made with a 15-fathom seine at 6 a. m. and the men were dressing fish from that one haul until 6 p. m. About 140 barrels were dressed. These were loaded in bulk into a small schooner, and then the men were occupied three hours in clearing the seine, in which the remaining salmon were about 4 feet deep.

The Humpback Salmon arrives at St. Paul, Kadiak, about the 10th of July, and there is only one run a year. From the statement of Mr. Hirsch, above referred to, it will be seen that it makes its appearance on the western side of the island at about the same time. Mr. Turner records the date of arrival at St. Michael's as about the 25th of July, and the period of running about five weeks. Nelson's earliest specimens were taken at St. Michael's July 24. He states that the species is rather numerous until the end of July, with more or less common stragglers until late in the fall. We found Humpbacks in good condition in Plover Bay, Siberia, about the middle of August.

The species continues to enter the rivers usually for a period of about five weeks, but it is not regular in its appearance. The enormous run in the Karluk, mentioned above, was exceptional, for the fish seldom enters that river. In the Yukon, during some years, according to Mr. Nelson, only a few are taken, and at other times they are present in such excessive numbers in the lower part of the river that the fish-traps must be emptied several times a day.

This salmon is much addicted to jumping out of the water. In the vicinity of St. Paul, Kadiak, one of the commonest sights was this breaching of the Humpback Salmon. Fishermen at this village told me that the sea run Humpback often contains a small fish, which, from their description, must be the capelin.

In the Karluk River, as already mentioned, the species continued to enter for five weeks, and then dead fish began to float down the stream, and this continued about a month. It does not go far from salt water and frequently enters streams which are too shallow to cover its fins. Its business in the fresh waters is simply to deposit its eggs, after which, apparently, it dies on the spawning-grounds or is carried to sea in a dying condition. Spawning takes place within a few rods of the sea. It is a common thing to see large areas of the bottom entirely covered with the eggs, either lying unprotected on the gravelly bottom or partly concealed in crevices between moderately large stones. In Afognak River the eggs were cast among stones about half as large as a man's fist.

There are no signs of diminution of the supply of this fish. A small number are salted annually, and the natives dry large quantities for winter use.

In the fresh run condition this is one of the most palatable salmon in Alaska, and the time is not far distant when it will be a very important species for canning. The flesh is somewhat paler than that of the Red Salmon, yet it has a beautiful color. Properly introduced into the markets this would become a very valuable fish, and its wonderful abundance would establish a great industry.

The height of the spawning season in the Kadiak streams is evidently about the middle of August. In Alexander's Creek, near the Larsen's Cove cannery of the Arctic Packing Company, Messrs. Lewis and Stone found the Humpbacks spawning in vast numbers August 15. Mr. Lewis took some of the eggs and fertilized them with the milt of the males. The eggs are larger than those of the Red Salmon, but smaller than King Salmon eggs and not so bright red. On the 22d of August we saw this

fish in the small streams at the head of the west arm of Uyak Bay trying to run up the rapids to spawn. The current in some places was so swift as to wash the fish away. Eggs were very plentiful between the crevices of the stones. On the 24th of August we found Alexander's Creek full of Humpbacks in all stages of emaciation and decay. In Alitak Bay, September 9, the fish were nearly all dead in the creeks, and Snug Harbor contained many dying Humpback Salmon floating seaward tail first. Messrs. Booth and Stone found Afognak River well filled with spawning Humpbacks August 30. The two tributaries of Afognak River also contained them in great numbers. Mr. Booth found the fish most abundant in the neighborhood of holes excavated in the egg-sized gravel of the bottom, intermingled with stones of 3 or 4 pounds in weight.

After the great run in the Karluk, already referred to, the fish came down dead or in a dying condition for a whole month and the beaches were strewn with dead salmon. The distortion of the Humpback during the breeding season is remarkable and the injury to its fins, and other exposed portions of the body, is excessive. The last stages of this species are repulsive to look upon, but before the extensive emaciation and sloughing away of the skin has taken place the colors of the breeding-fish are rather pleasing, the lower parts becoming milky white, contrasting beautifully with the darker color of the sides and back. This white color sometimes extends upward towards the middle line with interruptions.

The Red Salmon (*Oncorhynchus nerka*).

(Plate XLVIII, figs. 6 and 7.)

This is the blue-back of the lower Columbia River, the *Sawqui* or *Sukkegh* of Frazer's River, and the *Krasnaya Ryba* (or redfish) of the Russians. It does not seem to exist south of the Columbia River. Northward it is found as far as the Yukon, and occurs also in Japan and Kamchatka.

Although next to the smallest of the Pacific salmons this is now the most important species for canning and salting, and its flesh is so red as to win for it a reputation not warranted by its edible qualities. It approaches the shores early in the spring and enters only snow-fed streams. The Red Salmon is not caught, like the King Salmon and Silver Salmon, by trolling in the bays. When it comes into the mouths of the streams, to ascend for the purpose of spawning, the fishing begins.

The size of the Red Salmon varies with the locality and season. Some runs contain much larger fish than others. At Karluk the fish will average nearly 4 pounds apiece without the head, fins, tail, and viscera. The whole fish will weigh 7 or 8 pounds. Individuals of 15 pounds are occasionally seen, but they are uncommon.

Like the King Salmon, the Red Salmon travels long distances up the rivers, pushing on to their sources; unlike the King Salmon, however, the Red Salmon is chiefly a lake spawner, the former fish preferring the headwaters of the principal rivers to their small tributaries.

Red Salmon arrive at St. Paul, Kadiak, according to Mr. Washburn, agent of the Alaska Commercial Company, in June, and there is only one annual run. This gentleman also informed me that there is a little run of small Red Salmon in Little Afognak River as early as April 1, but the principal run comes in June or July. In a river just 10 miles distant from the Little Afognak the first run does not arrive until about May 20. At Karluk, in 1889, and around Kadiak generally, the species arrived late, and

the catch up to the end of July was small everywhere. Turner records the 1st of May as the time when the natives of Attu Island prepare weirs (*zapor* of the Russians) to obstruct the passage of the Red Salmon to their spawning-grounds. The species does not appear to be common on the coast of Norton Sound, according to Nelson, but it is more abundant in the Lower Yukon, the main run occurring about the middle of August and lasting sometimes only two or three days, but usually a week or ten days.

When we left Karluk at the end of August the Red Salmon were still running into that river, but had greatly diminished in numbers and had become so dark in color as to be unfit for canning. At Afognak the run usually lasts only during the first three weeks of July, although they first appear about the middle of June, and as already remarked, a few small ones occasionally come about the 1st of April. The runs of fish appear to vary a good deal from year to year. Some of the fishermen at St. Paul believe that every fourth year is a good salmon year. Mr. Charles Hirsch told me that in Cook's Inlet, the Ninilchic, Kusilov, Kenai, and Sushitna Rivers all have salmon runs, but the kind of fish varies from year to year. We have seen how an unexpected run of Humpbacks may prevent the Red Salmon altogether from entering its chosen river.

Mr. Hirsch says that in coming from the sea the Red Salmon approach from all directions. They have been seen about 1½ miles distant from the land, and when they approach nearer the schools break up. This species is very much given to jumping entirely out of water, and it is a common sight, where this fish abounds, to see a dozen or more in the air at a time. At Karluk the fish play around in the kelp beds, especially when frightened by the seines, and here they are perfectly safe from the fishermen. The Red Salmon does not linger long in salt water after its arrival on the coast. Fresh run fish sometimes go into the river with the tide and out again the same day with the ebb.

Young fish occasionally accompany the adults, but all of those examined by me proved to be males. On the 13th of August we obtained a male Red Salmon 11 inches long to the root of the tail. This example contained numerous intestinal worms.

It is asserted by Mr. Charles Hirsch and others, who have had much experience with the Red Salmon, that no spawning fish of this species ever leave Karluk River alive.

Natives of Karluk informed me that they can catch salmon at any time during the winter through the ice on Karluk River and lake. They assert, also, that all the Red Salmon die in the spring, most of them in April.

After entering the rivers the Red Salmon may return to the salt water as already stated, but if the spawning season be near at hand and the spawning grounds remote they travel up the stream very rapidly. I have seen them playing about in the rapids, apparently resting, during the ascent of the Karluk. Numerous beds of eel grass and other aquatic plants furnish attractive hiding places in which the fish sometimes linger.

The Red Salmon ascends to the lake or lakes, which the river drains, and it is said that this species will not enter a river which does not arise from a lake. The distance traveled in the Karluk is less than 20 miles, and the principal lake is 8 miles long. Red Salmon spawn in this lake and in the short and rapid rivers connecting each of its arms with smaller tributary lakes. The species ascends long rivers, like the Columbia, more than 1,000 miles, to reach its spawning lakes.

This salmon begins spawning soon after its arrival on the coast, and this varies with the locality. The season usually begins in June, and fish, which have not yet spawned, continue to arrive as late as the beginning of September. Spawning certainly takes place in August, as we know from personal observation. Dead fish and others which have spawned and are already dying are very abundant about the middle of this month. We did not find many Red Salmon on our way up the Karluk River. In Karluk Lake, near the sources of the river, ripe Red Salmon were speared by the natives August 17. On the 18th of the same month we found large numbers of dead salmon of this species, and plenty of both sexes, which were spent and nearly dead, in the rivers connecting Karluk Lake with its tributary lakes. In all of the little streams falling into Karluk Lake, in which Red Salmon were found, dead fish were moderately common. We found, also, an abundance of young salmon about 1½ inches long, which I suppose must have been young of the year, hatched from eggs deposited during the preceding winter. Mr. Charles Hirsch informed me that "in March or April the Karluk River is solid full for a whole month of salmon fry going down to sea."

We found salmon nests at the head of Karluk Lake in shallow water near the shore between the mouths of two streams. The nest is a hollow circular pile of stones, and the eggs are placed in the crevices between the stones. In the river connecting the east arm of Karluk Lake with its tributary additional nests of the salmon were observed. In some cases streams fall down into Karluk Lake over bluffs, which are too steep for the salmon to ascend, and the fish were spawning at the mouths of such streams.

Extensive changes take place in the color of the Red Salmon as the spawning season approaches. When it comes in from the sea the skin becomes dark and the beautiful red color of the flesh gives place to a paler tint. In this condition the fish has no commercial value. In the height of the spawning season the sides are suffused with a brilliant vermilion and the head is a rich olive-green, contrasting sharply with the color of the body. The male develops a hump, nearly as large as that of the Humpback, and its jaws are greatly enlarged.

The eggs and young of the Red Salmon have many enemies, and the percentage of fish naturally developed from eggs must be exceedingly small. Every salmon nest has its greedy horde of little fresh-water sculpins, otherwise known as Miller's thumbs, blobs and bull-heads (*Uranidea* spp.), always in readiness to consume the fresh eggs in quantities out of all proportion to their size. The shoal waters around the shores of Karluk Lake, and the shallow streams into which the Red Salmon finds its way for reproduction, contain myriads of these destructive little sculpins. Another source of destruction to the eggs is found in the dolly varden trout (*Salvelinus malma*), which is only too common on the spawning grounds of the salmon. This trout consumes large quantities of the fresh salmon eggs. The waters referred to contain, also, a great many sticklebacks (*Gasterosteus* sp.), some of them of very large size, and it is probable that these little fish destroy eggs.

Chief among the destroyers of the young fish are terns, gulls, ducks, and loons, which are very common in that region. I shot some terns and gulls near the south end of Karluk Lake and upon holding them up by the legs small salmon dropped out of their mouths. Towards the end of August the shallow parts of Karluk River were visited by hundreds of gulls, chiefly young of *Larus glaucescens* and *L. brachyrhynchus*,

which were feeding upon young salmon. Bears consume large quantities of the breeding fish. They may be seen standing at the edge of the stream, where the water is shallow, and occasionally striking salmon with their claws and throwing them on the shore, where they are eaten alive. We found a dolly varden trout just released by a bear which our approach frightened away. One of the gill-covers of this fish was half torn off, but no other injury was visible. We saw Red Salmon partly eaten, but still alive, lying on the shore after the retreat of the bears, which were disturbed while feeding. Other enemies of the salmon attack it in the sea. Among them are the salmon shark (*Lamna cornubica*), porpoises, and sea-lions. We found all the species of salmon more or less covered with parasitic *copepods*. Collections of these were made, but the species have not been determined. At Afognak Mr. Booth observed a very serious cause of destruction of salmon. The estuary of Afognak River is generally left bare at low tide and great numbers of salmon are thus stranded, many of which die before the next tide rescues them.

Red Salmon are seen in salt water off the mouths of the rivers in large schools in the spring. The season of their approach to the shores has already been referred to, and also the fact that they are not observed farther than about 1½ miles from the shore. No attempt has been made to take Red Salmon until it comes to the shore. It is not caught by trolling, like the King Salmon and the Silver Salmon.

The catch of Red Salmon has been increasing, owing to the increase in the number of persons engaged in the fishery and in the effectiveness of the implements used in its capture. The size of seines has been greatly enlarged and the number of boats, seines and men largely augmented. That there will be a falling off in the supply very soon there can be no doubt. I have already remarked that the number of spawning fish in Karluk Lake and its tributaries last year was unexpectedly small. It is true that young salmon, from 1½ inches to 2 inches in length, were very abundant, but they were the result of the spawning of the previous season.

There was early in the season of 1889, and in previous seasons, injudicious obstruction of the ascent of spawning fish in the Karluk River. At one time an impassable weir, similar to the *zapor* of the Russians, was placed in this river. At the time of our visit we saw the remains of pound nets made of wire netting, which interfered so seriously with the ascent of the fish that they were dismantled by unknown parties and were not re-established.

The Steel Head (*Salmo gairdneri*).

(Plate XLIX, figs. 9 and 10.)

This large black spotted trout is known also as Hard-head and Gairdner's trout. The Russian name is *Soomga*. In some of our eastern markets, at this date, it is the "Kennebec Salmon."

This species sometimes reaches a weight of 30 pounds, and individuals of that size bear a close resemblance to *S. salar*. The Steel-head is found from Monterey, California, to Bristol Bay, Alaska, and is very abundant in some parts of the Gulf of Alaska. This trout has been considered a winter spawner, but females full of ripe eggs were seen by me near Sitka, June 10, 1880. Spent fish of this species are frequently taken with the spring run of the King Salmon, so that in all probability the usual spawning time is late in the winter or very early spring.

This species, according to Mr. Charles Hirsch, arrives at Karluk in August in small numbers. I saw a moderately large number of Steel-heads at Karluk on September 4, but their abundance was nothing in comparison with that of other species. It is seldom used at Karluk. I saw a few small individuals in process of drying there.

The spawning habits of the Steel-head are scarcely known. At Sitka we were told that it spawns in lakes not far from the sea and immediately after spawning goes into the salt water.

Another large black spotted species is Clark's trout (*Salmo purpuratus*, Plate XLIX, fig. 11). This occurs in southern Alaska and north to the Bristol Bay region; it grows to a length of 30 inches, and must soon become commercially valuable.

The Dolly Varden Trout (*Salvelinus malma.*)

(Plate XLVIII, fig. 8.)

This handsome species bears a very close resemblance to the sea trout of Labrador. It is known to commerce under the name of Salmon Trout. In some parts of the West it is called the Bull Trout. The Russian name of the species is *Goletz*, and in Kamtchatka it is the *malma.*

The average weight of this trout in the sea fishery at Kadiak is about 2½ pounds. It reaches a length of 30 inches, and individuals weighing 8 pounds are often taken. It increases in size to the northward.

The Dolly Varden is a migratory species and passes much of its time in the sea near the river mouths; it enters the rivers late in the fall and descends in the spring. At St. Paul Mr. Washburn informed me that it arrives at that place in April. It remains in the bay near St. Paul throughout the summer. Mr. Charles Hirsch told me that it reaches Karluk in the latter part of May and runs through the whole season. Dolly Vardens of a pound or more can be found in the streams at any time during the summer. We saw them in abundance throughout the Karluk in August, and in the small streams tributary to Karluk Lake. Nelson found them at Unalashka early in June, and in the Yukon in the same month, but he says they are most numerous in the fall just before and after the streams freeze over. They enter the rivers and go up to their headwaters for the purpose of spawning. The spawning season is in winter and may begin very early in this part of the year. A female, opened on the beach at Karluk August 2, contained eggs which seemed to be nearly ripe.

Individuals taken at sea sometimes have capelin in their stomachs. In Karluk River, near its mouth, we saw many examples feeding on eggs of the Red Salmon, which had been thrown into the water from the fish-cleaning houses. On the 5th of August we found a female Dolly Varden with very small ovaries. This example was long and slender. On August 16 a spent or sterile *malma* was found above the rapids in a little stream tributary to Karluk River. At the head of Karluk Lake, August 19, was discovered a very much emaciated trout of this species, which was struggling in the water and nearly dead. The inside of its mouth was full of large lernæan parasites.

The Dolly Varden spends the entire summer in salt water near the mouths of the rivers after it has reached a certain age; younger individuals remain in the rivers and lakes. Many thousands of this trout are caught in the seines hauled for salmon, and

fisheries exist for this species alone in various localities. It is put up in pickle and sold in San Francisco. The demand there, however, is limited.

No diminution of the supply of this trout has been observed. There is great destruction of this fish at Karluk in the seining for Red Salmon, where thousands of Dolly Vardens are taken and left lying unused on the beach. Something should be done to prevent this waste of good fish. Bears destroy a great many of these trout and water birds consume immense numbers of the young. At sea sharks, porpoises, seals, and sea-lions prey extensively upon the adults.

METHODS, CONDITIONS, AND STATISTICS OF THE SALMON FISHERIES.

APPLIANCES AND METHODS.

The fleet engaged in carrying cannery outfits, supplies, men, and products in the season of 1889 included 13 steamers, 4 steam schooners, 1 ship, 13 barks, 2 brigs, 10 barkentines, and 23 schooners, a total of 66 vessels.

The earliest clearing date which I have observed was January 30, and the latest on my list is September 20, 1889. Many of these vessels are chartered by the fishing companies for the season or the trip.

The number of dories employed at Karluk is about 200; the Karluk Packing Company alone has more than 50. At Afognak about 40 dories are used, and the number in Alitak Bay is probably not over 50. Several of the canning companies have steam launches for towing their scows and lighters. All of the companies have a sufficient number of the latter for loading and unloading their vessels, and all handling of freight to and from vessels must be done by means of the scows and lighters, as there are no wharves on the bay and no possibility of establishing them. The steam launches can tow lighters and flat-boats into the river at high tide, but not during low water nor on the half tide. Columbia River boats are used to some extent by the fishing companies at Kadiak, chiefly for making short voyages between stations.

Most of the fish used in the canneries are caught in seines varying from 150 to 250 fathoms in length, and from 16 to 20 feet in depth. The usual size of the mesh is 3¼ inches. Gill-nets also are used at Karluk, in Prince William Sound, and some other localities. Soft-laid twine is preferred to the hard laid for beach seining at Karluk, as it does not chafe so much on the rocks. A purse-seine was used August 7 by Mr. Barker outside of the kelp, and did reasonably well. The kelp is a great hindrance to the seining at Karluk, but affords excellent shelter for the salmon. The bottom of the bay is thickly covered with it, and its fronds float up to the surface except over about a half mile adjacent to the river mouth. The species is known as Bull-kelp.

We were informed that 36 canneries were in operation in Alaska in 1889, and we are indebted to Capt. H. E. Nichols, of the U. S. Coast Survey, for a chart showing the locations as nearly as could be ascertained. The canneries are situated as follows: Eight are on Kadiak Island, and 2 on Afognak; on the Nushagak there are 4; on the east side of the peninsula of Alaska, 5; in Cook's Inlet, 2; in Prince William Sound, 2; on Kayak Island, 2; in Lynn Canal, 3; Icy Strait, 1; Takou River, 1; Baranoff

Island, 1; Stickene River, 1; Klawak, 1; in Behm Canal, 3; in Tongass Narrows, 1, and at Port Tongass 1—the last doubtful.

The exact value of the buildings and machinery was not ascertained. The capital stock of the companies, however, varies from about $75,000 to $300,000, and it is fair to estimate the capital invested in this business at not less than $4,000,000.

The printed list of the salmon canneries on the Alaskan coast is taken from the San Francisco Commercial Herald and Market Review.

Salmon canneries of Alaska.

(Plate LXXXVII.)

Name of company.	Where located.	Brand.	Agents.	Home office.
Alaska Coast Fishing Co	Kadiak Island		Cutting Packing Co	San Francisco.
Alaska Packing Co	Nushagak	Polar Bear, Ice King	D. L. Beck & Sons	Do.
Alaska Salmon Packing and Fur Co.	Loring	Naha Bay Brand	Cutting Packing Co	Do.
Alaska Improvement Co	Kanatak & Kadiak	Canoe	James Madison	Do.
Aleutian Islands F. & M. Co	Kadiak Island	Kodiak	Scotchler & Gibbs	Do.
Arctic Fishing Co	Cook's Inlet	Arctic	Cutting Packing Co	Do.
Arctic Packing Co	Bristol Bay	Red, King, and Silver	C. C. Rohlffs	Do.
Arctic Packing Co	Karluk	Red, Aurora Borealis	do	Do.
Baranoff Packing Co	Clarence Straits	Wigwam	Williams, Brown & Co	Do.
Bartlett Bay Packing Co	Bartlett Bay		do	Do.
Boston F. & T. Co	Yes Bay	Sea Lion	do	Do.
Bristol Bay Canning Co	Bristol Bay	Polar and Excelsior	W. B. Bradford	Do.
Chilkat Packing Co	Chilkat	Glacier	Frank H. Foote	Do.
Chilkat Canning Co	Pyramid Harbor		Murray & Co	Astoria, Oregon.
Chignik Packing Co	Chignik	Our Taste	S. B. Peterson	San Francisco.
Chignik Bay Co	Chignik Bay	Comet, Guardian, and Crown.	D. L. Beck & Sons	Do.
Central Alaska Co		Northern Light	Scotchler & Gibbs	Do.
Moira Packing Co	Cape Fox	Moira	Taylor, Young & Co	Portland, Oregon.
Cape Lees Packing Co	Cape Lees	Iceberg and Totem-stick.	Townsend, McGovern & Co.	San Francisco.
Glacier Packing Co	Stikeen	Lion and Neptune	Delafield, McGovern & Co.	Do.
Hume Packing Co	Kadiak	Karluk	George W. Hume & Co	Do.
Kodiak Packing Co	do	North Pole and U. S. brand.	Kodiak Packing Co	Do.
Karluk Packing Co	Kadiak Island	Horseshoe	Karluk Packing Co	Do.
Nushagak Canning Co	Nushagak	Moose Head Brand, Red, King, and Silver.	Louis Sloss & Co	Do.
Northern Packing Co	Kenai	Anchor Brand, Red, King, and Silver.	do	Do.
Northwest Packing and Trading Co.	Klawack	Challenge	R. A. Wilson	Do.
Pacific Packing Co	Prince William Sound.	National	Louis Sloss & Co	Do.
Pacific Whaling Co	Copper River	Orca	Capt. J. N. Knowles	Do.
Peninsular Trading and Fur Co		Compass	Scotchler & Gibbs	Do.
Prince of Wales	Prince of Wales Island.	Coat of Arms	Cutting Packing Co	Do.
Pyramid Harbor Packing Co	Pyramid Harbor	Raven	D. L. Beck & Sons	Do.
Royal Packing Co	Afognak	Chieftain	Louis Sloss & Co	Do.
Russian-American Packing Co	do	Russian-American Brand	Russian-American Packing Co.	Do.
Shumagin Packing Co	Chignik	Warren's Alaska	W. D. Smith	Astoria, Oregon.
Thin Point Packing Co	Thin Point	Coleman's Flag	L. Sloss & Co	San Francisco.
Western Alaska Packing Co	Ozernoy	Walrus	W. B. Bradford	Do.

The canneries at Karluk, and on Kadiak generally, get their supply of fresh water from the adjacent mountain streams. At Karluk they make little reservoirs at suitable elevations and from these carry the water by surface pipes of iron into the canneries, thus utilizing the force of gravity.

The plant of a canning company usually includes, besides a cannery building proper, a fish house and wharf, a salting house, containing tanks for curing salmon, a cooper shop, barrel house, a machine-shop, a lodging-house and mess-room, a store-room and a warehouse. The method of handling the salmon after they are caught is as follows: The fish are thrown from the boats into large bins in the splitting-house, where they

are prepared for the cannery by cutting off the heads and fins, and removing the viscera. The different steps in this process are performed by different groups of men, one set cutting off the heads, another removing the fins, while still another scrapes out the viscera. After this the fish are washed and finally thrown into hand carts, to be hauled into the cannery, where they pass through various processes, almost all of which are carried on by machinery. The Red Salmon is first cut into lengths suitable for the size of the can. These pieces are carried along and fed into cans, inequalities in the filling being supplied by hand work. The cans are then topped in the topping machine, from which they pass to the soldering machine, and then are subjected to the processes of venting, cooking, steaming, testing, cooling, japanning and labeling.

The number of canneries in Alaska was greatly increased in 1889. Prior to 1888 the islands of Kadiak and Afognak contained only one or two establishments. The Karluk Packing Company at Karluk was the largest. In 1889 the number of canneries at Karluk was increased to five, and three additional firms came to that place to seine fish for canneries located at other places. The yield in 1889 was larger than in 1888, so that no decrease in the number of salmon has been observed as yet; of course the catch has been divided among a large number of companies and the individual take has fallen off in some cases. As an illustration of the injurious effects of over seining at Karluk it may be stated that previous to 1889 seining was carried on almost exclusively in Karluk River and there was no fishing done on the ocean beach except at very low tides, when there was not enough water to seine in the river. In 1888 a seine of 100 fathoms set in Karluk River took 17,000 fish at one haul. In 1889 the rivalry to obtain fish was so great that seining was done principally in salt water, as near the river mouth as possible, and the length of the seines was increased in most cases to 250 fathoms.

PRODUCTS OF THE SALMON FISHERY.

The productive streams of the Territory are generally small and have their sources in large lakes. The great rivers of the Territory from the Bristol Bay region northward do not furnish the yield which we might reasonably expect from their superior size, but these rivers are in the nature of undeveloped territory, with the exception of the Nushagak.

Nearly one-half of the entire yield of salmon in Alaska is now taken near the mouth of a small river, the Karluk, which at low water is only a few yards wide and has a length of less than 20 miles.

According to the Commercial Herald and Market Review, of San Francisco, the Alaska salmon pack of 1889 amounted to 629,260 cases in cans and 6,930½ barrels in salt. Two thousand cases of 48 pounds each is considered a great day's work for a first-class cannery, and is seldom exceeded, but on the 5th of August, 1889, the Karluk Packing Company canned 2,412 cases by extraordinary efforts.

The value of the output for 1889 was nearly $3,000,000. The market returns given below will show what share the different companies had in this yield.

Alaska salmon pack of 1889.

Arrived.		Vessel.	Barrels.	Cases.	Agents.
June	10	Bertha, str		3,665	Karluk Packing Co.
July	20	Jeanie, str		5,000	Pacific Steam Whaling Co.
	21	Ida Schnauer, sch		6,615	Alaska Improvement Co.
	23	Bertha, str		12,194	Karluk Packing Co.
	31	C. C. Funk, bkt		1,648	Western Alaska Packing Co.
	31	Hope, bk	31	10,400	Aleutian Island F. & M. Co.
Aug.	5	F. S. Redfield, sch		1,400	Scotchler & Gibbs.
	7	Comet, sch		5,035	Bradley & Co.
	10	Courtny Ford, bg		7,539	D. L. Beck & Sons.
	12	N. Thayer, bk		13,206	Arctic Packing Co. & Rus. Amer. P. Co.
	14	Jennie Stella, sch	59	8,000	Arctic Packing Co.
	19	Modoc, bkt		5,000	Chignik Bay Packing Co.
	27	St. Paul, str		3,600	Thin Point Packing Co.
	28	Louis, sch		12,767	Hume Packing Co.
	28	Vesta, sch		12,145	Karluk Packing Co.
	29	Sonoma, bk		19,644	D. L. Beck & Sons.
Sept.	1	Sea Waif, bg		1,250	Bristol Bay Packing Co.
	10	Electra, bk	130	27,764	Nuchigak Packing Co.
	10	Will W. Case, bk	6	16,220	Arctic Packing Co.
	10	Retriever, bkt		18,711	Northern Packing Co.
	11	Bertha, str		16,500	Karluk Packing Co.
	11	Jennie, str	69		Northern Packing Co.
	16	Oneida, sch	232	5,013	Pacific Packing Co.
	21	Ida Schnauer, sch	126	9,211	Arctic Fishing Co.
	21	Harry Morse, bk		361	Central Alaska Co.
	22	Wm. Renton, sch		2,540	Peninsular T. & F. Co.
	22	Haytien Republic, str	146	24,069	Kodiak Packing Co.
	22	...do		5,529	Arctic Packing Co.
	26	Jeanie, str	60	9,830	Pacific Steam Whaling Co.
	27	J. A. Borland, bk	73	19,553	Thin Point Packing Co.
	28	City of Puebla, str	127	13,645	Various.
Oct.	8	M. Winkleman		14,299	D. L. Beck & Sons.
	8	K. Flickinger, bkt		5,536	Chignik Bay Packing Co.
	8	Dashing Wave	503		Lynde & Hough.
	8	Viking, sch	33	2,880	Arctic Packing Co.
	8	Al-Ki, str	293	21,003	Various.
	8	Cas. Hayward, sch	890		Glacier F. & T. Co.
	9	Portland, bkt		6,158	Shumagin Packing Co.
	9	Laura Madsen, sch	152	13,794	Arctic Packing Co.
	10	Elsinore, bk		3,037	Western Alaska Packing Co.
	11	Margaret, bk		22,561	Russian-American Packing Co.
	11	Alden Besse, bk	14	31,300	Scotchler & Gibbs.
	12	Corea, bk	64	21,608	Arctic Fishing Co.
	14	Novelty, sch		14,412	Royal Packing Co.
	14	...do		5,686	Karluk Packing Co.
	14	...do	450		Arctic Fishing Co.
	22	St. Paul, str		1,900	Thin Point Packing Co.
	25	Farallon, str	6½	11,100	Bristol Bay Canning Co.
	26	Kodiak, sch	369	353	Karluk Packing Co.
	27	Dora, str		108	Alaska Commercial Co.
	28	Hera, sch	693	3,287	Golden Gate Salmon Co.
	28	Hattie Gage, str		605	Scotchler & Gibbs.
	28	Coryphene, bk		21,833	Hume Packing Co.
	28	Bertha, str	6	8,939	Karluk Packing Co.
	29	Beulah, sch	77	11,370	N. Pacif. Trading and Packing Co.
	29	Quickstep, bkt		12,364	Alaska Improvement Co.
	29	Dora, str		108	Thin Point Packing Co.
	29	Karluk, str		3,462	Karluk Packing Co.
	30	Nic. Thayer, bk		16,592	Arctic Packing Co.
	31	Undaunted, sch	375		Bowen, Colwell & Co.
Nov.	3	Hope, bk		19,122	Aleutian Island Fshg. & Mng. Co.
	3	Alaska, str	27		Arctic Packing Co.
	4	Arago, sch	43	3,763	Baranoff Packing Co.
	5	Signal, str		18,500	Bristol Bay Canning Co.
	9	Haytien Republic, str	6	18,538	Kodiak Packing Co.
	10	Corona, str	481	8,952	Various.
		Various	139	9,286	Do.

PREPARATION OF FISHERY PRODUCTS.

The native methods of curing salmon by sun drying and smoking have been so often described that I need not refer to them here. The processes of canning have also been fully recorded. The following notes on the method of salting Humpback Salmon at St. Paul will sufficiently describe the method of salting in general. Salting Humpbacks began at St. Paul about the 10th of July. The first dory load of

"colored" fish was brought in July 29. The percentage of both sexes, whose flesh is becoming light while the skin grows darker, is large. One can tell with almost certainty from looking at the outside just what the inside appearance of the fish will prove to be; a bright silvery female and a male with scarcely developed hump will show flesh of a very pretty pink, though not so red as in the *nerka*; a fish with dark slaty sides and head will have pale flesh; of course the male and female in the height of the breeding season have very pale meat.

The *gorbuscha* exceeds in numbers all the other species; in the prime condition it is as good to eat as any other salmon. The salting season for prime fish is short, only a few weeks as a rule.

The dory carries three men who seine the fish best on half or three-fourths tide and bring them to the wharf to be split for salting. The load averages 10 barrels of eighty fish each. A little saltpeter is used to set the pink color and, if possible, deepen it. A boy gaffs the fish to a place near the splitting table, where another boy cuts off the heads and passes the body to the splitters. The two splitters make a cut along the left side near the dorsal outline, ending it with a little downward curve on the tail. The viscera are scraped out and the backbone cut away; a few moves of the knife scrape away the blood and other gurry, and then the fish are thrown into a washing vat with two compartments, one for red fleshed fish, the other for pale. The Aleuts buy the latter and are said to prefer the male with a decided hump. At all events they select such fish when given permission to take some home for the table. After the fish are washed and rubbed clean with a broom they are placed in a perforated box and wheeled on a truck to the salting house. For the first salting one-half sack of salt is used for a barrel of salmon; the fish remain in the first pickle about a week; for repacking one sack of salt is needed for three barrels of 200 pounds each. The fish are washed in the pickle and rubbed clean with a scrub-brush before repacking.

TRANSPORTATION AND MARKETS.

Elsewhere will be found a statement to the effect that sixty-six vessels were engaged during the season of 1889 in the Alaskan salmon trade. The products of the fisheries are consigned to the agents of the companies, in San Francisco, Astoria, and Portland, who dispose of them in foreign markets, principally in England.

FINANCIAL ORGANIZATION.

The fishermen of Kadiak as a rule receive $40 a month, and board and lodging, for their work, besides $5 a thousand for the fish they catch. They are carried to Alaska and back without expense to themselves. I have been informed that the average earnings of the fishermen for six months are about $300. Most of the work in the canneries is done by Chinese, whose services are obtained by contract with their agents in San Francisco. The information in my hands respecting the value of vessels, boats, apparatus, etc., does not cover the ground sufficiently to present it in this place.

THE FISHERMEN.

The number of native fishermen employed at Kadiak is very small. At Karluk one of the companies, the Karluk Packing Company, has about twenty of the natives for one of its seining gangs, but their work is not so satisfactory as that of the white men.

It is said to be very difficult to keep the natives engaged. At Afognak many of the natives are employed about the canneries as carpenters. They are engaged, also, in making boats of various kinds and their labor in this direction is appreciated. The presence of the canneries has not diminished the fish supply of the natives as far as I could learn; it is really easier for them to obtain what they need for winter use than it was before the opening of the canneries. The natives, however, had nets, seines, and other appliances for catching fish before the white men came among them. If the supply of fish should become exhausted by overfishing or any other cause, the effect would be to starve the natives in all localities in which fish is the principal food supply; but if they are sufficiently interested in their own welfare to work for a living, they can get more salmon now than they could before the days of canneries, and will receive good wages and be well supplied with provisions. One great source of trouble with the natives is caused by the illegal sale of intoxicants by the Chinese and, occasionally, some Americans. This traffic is the means of destroying the usefulness of the people and renders them more liable to pulmonary diseases.

Most of the work in the canneries, as already stated, is done by Chinese; the superintendents and other principal men about the canneries are mainly Americans. Among the fishermen may be found Americans, Norwegians, Swedes, Germans, Sicilians, and negroes.

ARTIFICIAL PROPAGATION OF THE SALMON IN ALASKAN RIVERS.

The observations of our party at Alexander's Creek, Uyak Bay, on the naturally deposited eggs of the Humpback Salmon, *Oncorhynchus gorbuscha*, showed that they are a little larger than those of the Red Salmon, *O. nerka*, and a little smaller than King Salmon eggs, *O. chouicha*. Their diameter is about one-fifth of an inch. Mr. Lewis fertilized some of these eggs with the milt of the males and found no difficulty in handling them. Eggs of Red Salmon, *O. nerka*, as already mentioned, were seen in nests around Karluk Lake and the rivers connecting it with its two tributary lakes.

There are no extraordinary difficulties in the way of establishing hatching stations for Red Salmon and Silver Salmon in many of the bays of Kadiak. Alitak Bay and Afognak Bay furnish localities entirely suitable for the undertaking, and I can not see any reason why a hatchery at Karluk might not be practicable and desirable. The canneries get their supply of fresh water with no other trouble than that of piping it in surface pipes from hill-side reservoirs. Lumber, machinery, and workmen are brought from San Francisco. Salmon are extremely abundant. There is no sheltered harbor, but extensive loading and unloading go on with safety in good weather. Supplies can be had the year around. The winter cold is not excessive.

It would undoubtedly be difficult to sustain a hatchery on Karluk Lake, and it may not be necessary to locate one there if the spawning salmon are allowed to go up the river in sufficient numbers. If, however, it should be desirable to occupy the lake for this purpose a road must be constructed from the west end of Larsen's Cove, and Mr. Booth advises that it follow along the foot-hills of the mountain range which bounds the river valley on the east, the valley itself being unsuitable for a road on account of its boggy nature. Lumber would have to be carried to the lake, as the native timber is fit only for fuel.

From what I have heard about Thin Point, on the peninsula of Alaska, it appears to me that the river at that place is well adapted for fish culture; it is short, rapid, constant, and has its source in a large lake. Nearly 20,000 cases of Red Salmon were taken there in 1889.

Alitak Bay has good harbors and several good salmon streams, with plenty of pure water that can be obtained by gravitation.

Messrs. Booth and Stone visited Afognak and were very favorably impressed with the outlook for salmon hatching on the Litnik River. Mr. Booth's report contains the following items of especial interest in this connection:

"Afognak River, especially near the falls, would furnish a very convenient site for hatching purposes. It is near a harbor safe in all directions from storms, has an abundant supply of fresh cold water at all seasons, and abundant timber, which, though not adapted for first-class lumber on account of knots and pitch, is still avail-

able for the many purposes for which second-class material is as good as first-class in that locality.

"Any of the small so-called single portable mills would speedily and cheaply convert portions of these forests into useful shape, and, so long as only enough is cut to supply those having establishments on the islands, no law need be violated.

"In addition to the advantages before mentioned, labor is much easier to obtain here than at many other possible locations. At the village of Afognak, 4 miles from the canneries, native carpenters and boat-builders can be found who could be employed, as they have been by the Royal Packing Company, in the construction of buildings under the supervision of an intelligent American mechanic. These native carpenters are, in most cases, rapid and thorough workmen. Mr. Blodgett, of the Royal Packing Company, showed us a lighter built by them at a cost, including lumber, of $40. A precisely similar one built in San Francisco cost $175, not including freightage to Alaska. The cannery building of the same company, erected in 1888, was built almost entirely by native labor, and is accounted the most substantial cannery building in Alaska. These men also build dories and skiffs and are employed constantly for this purpose by many of the Karluk companies.

"Besides buildings, a short road from the canneries to the site selected would have to be made, as the estuary and upper part of the bay are too shallow for water transportation even in boats. Two small timber bridges about 30 feet in length would be required at the crossing of the two tributary creeks.

"The run of Red Salmon is fairly abundant, but short, lasting only the first three weeks of July, the fish first appearing, however, in the middle of June." [This does not take into account the run of small Red Salmon in April.]

Mr. Stone, to whom the subject of fish cultural operations was especially referred, has entered very fully into the advantages of the Litnik for an initial station, and I will merely call attention to his recapitulation, leaving the details to his complete report. He finds in the Litnik—

(1) A river that is easily controlled and is not subject to excessive fluctuations of rise and fall.

(2) An unlimited supply of water for the hatching-house, furnished by gravitation.

(3) Favorable conditions for capturing the breeding fish.

(4) A central and comparatively accessible location.

He states, further, that the four desirable species of Salmonidæ—Red Salmon, Silver Salmon, Humpbacks, and Dolly Varden Trout (or Salmon Trout)—all ascend the Litnik.

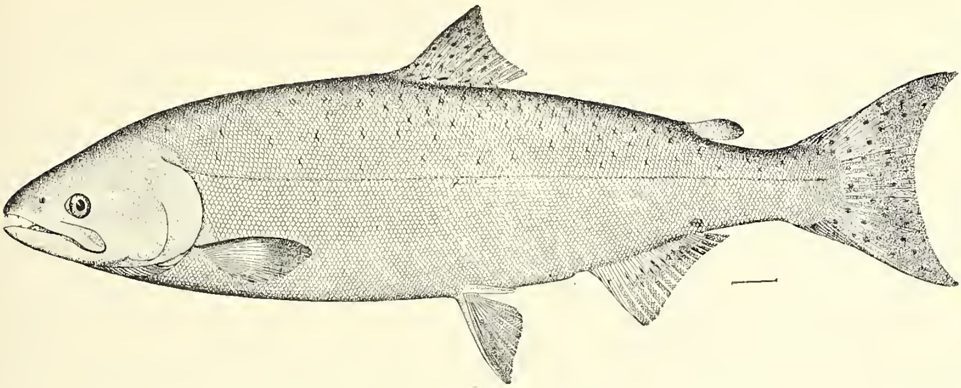


FIG. 1. THE KING SALMON (*Oncorhynchus chouicha*). (See page 190.)

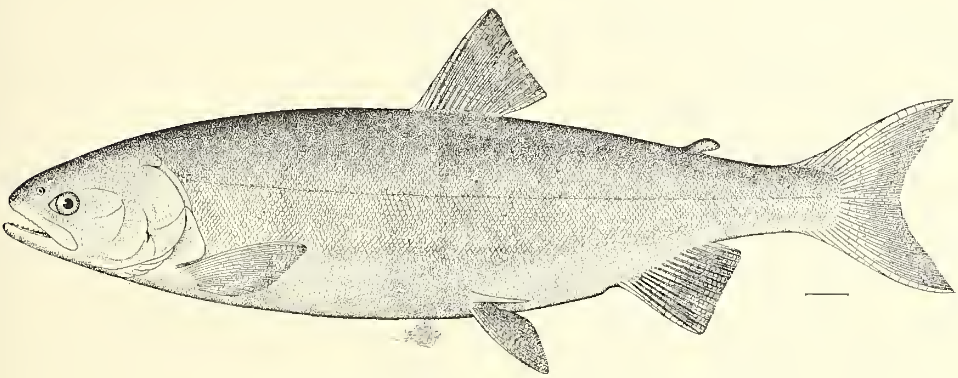


FIG. 2. THE DOG SALMON (*Oncorhynchus keta*). (See page 192.)

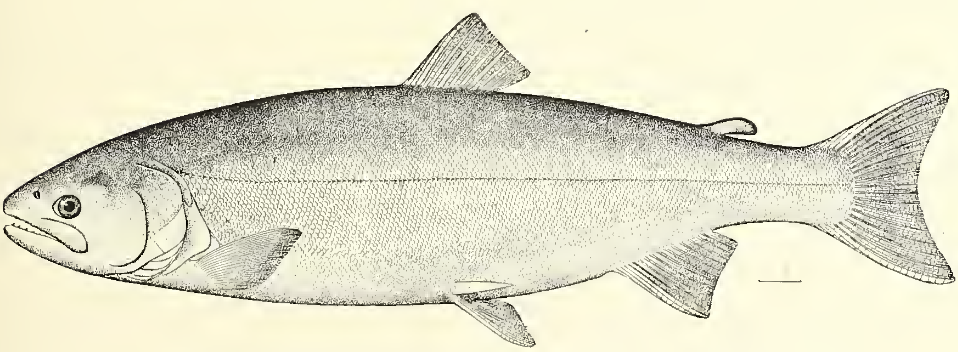


FIG. 3. THE SILVER SALMON (*Oncorhynchus kisutch*). (See page 192.)

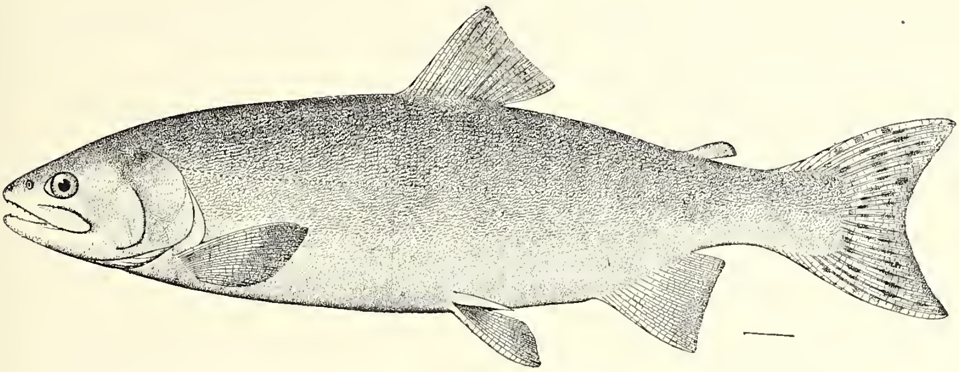


FIG. 4. THE HUMPBACK SALMON (*Oncorhynchus gorbuscha*). Sea-run. (See page 193.)

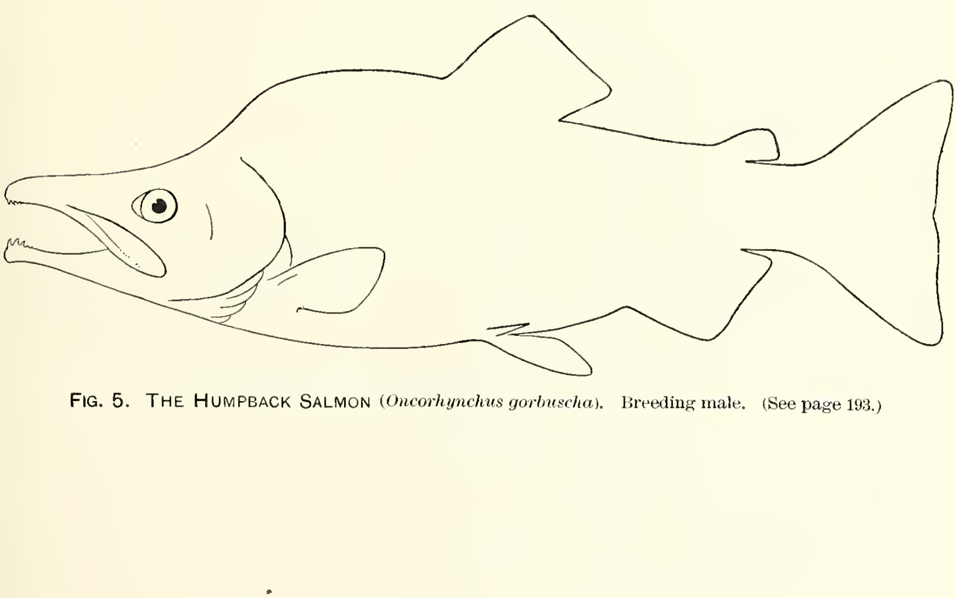


FIG. 5. THE HUMPBACK SALMON (*Oncorhynchus gorbuscha*). Breeding male. (See page 193.)

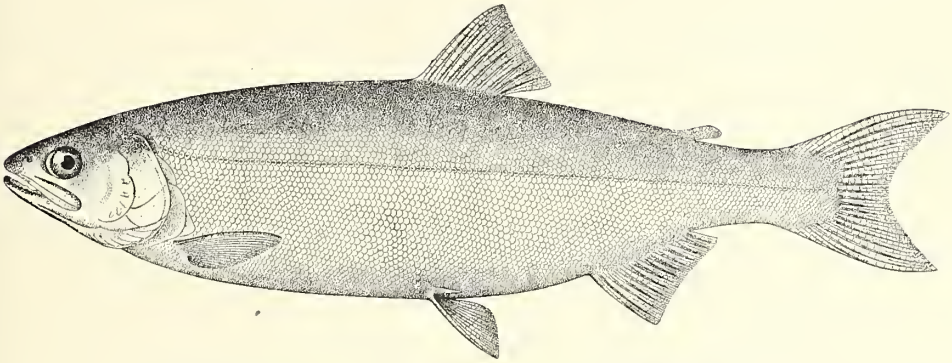


FIG. 6. THE RED SALMON (*Oncorhynchus nerka*). Sea-run. (See page 195.)

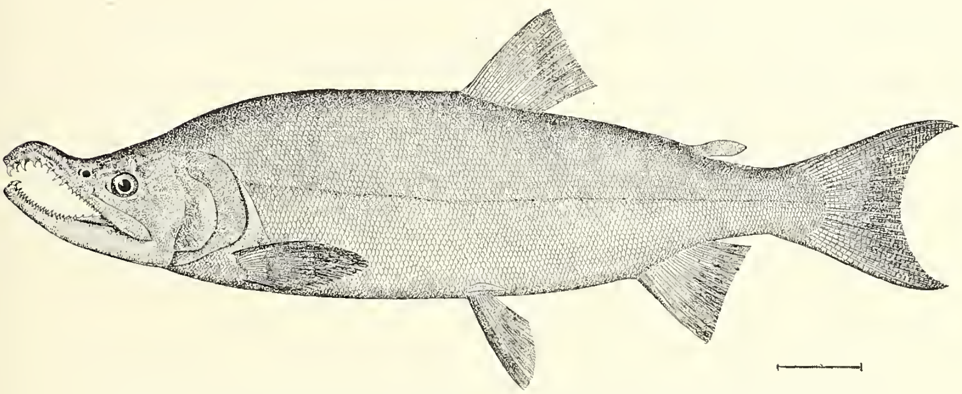


FIG. 7. THE RED SALMON (*Oncorhynchus nerka*). Breeding male. (See page 195.)

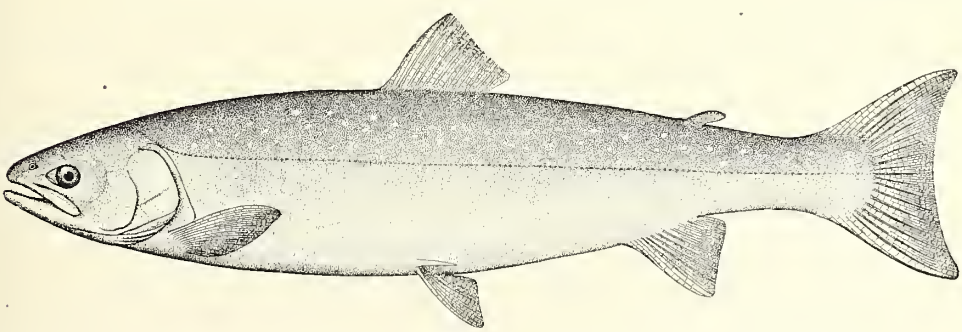


FIG. 8. THE DOLLY VARDEN TROUT (*Salvelinus malma*). (See page 199.)

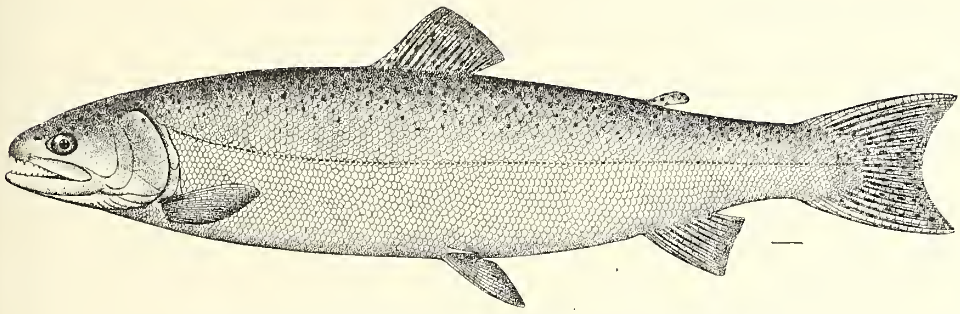


FIG. 9. THE STEEL HEAD (*Salmo gairdneri*). Adult. (See page 198.)

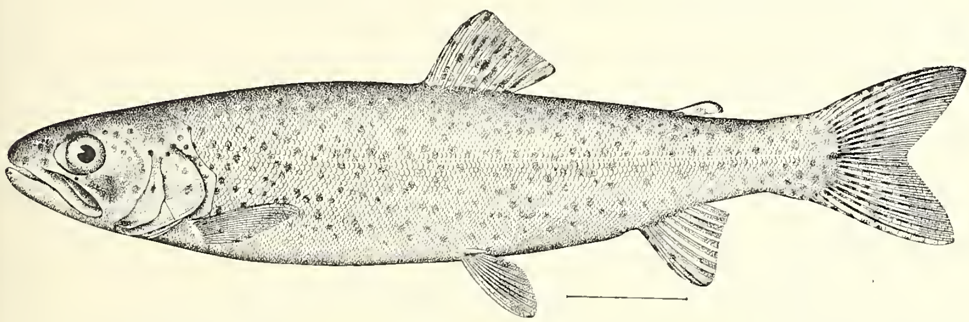


FIG. 10. THE STEEL HEAD (*Salmo gairdneri*). Young. (See page 198.)

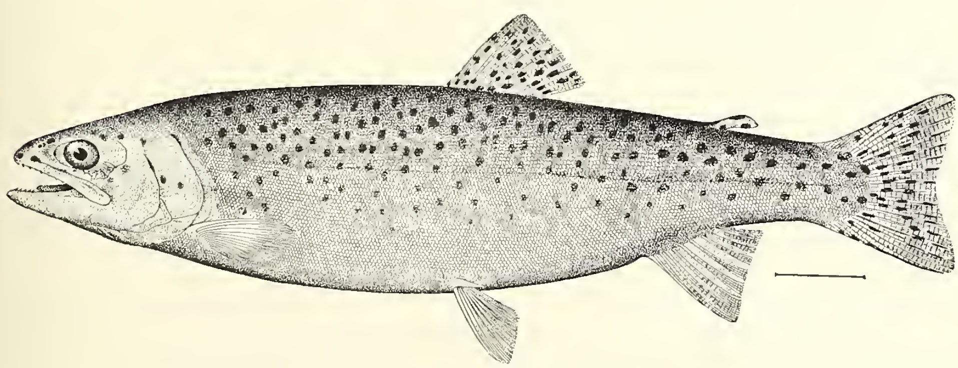


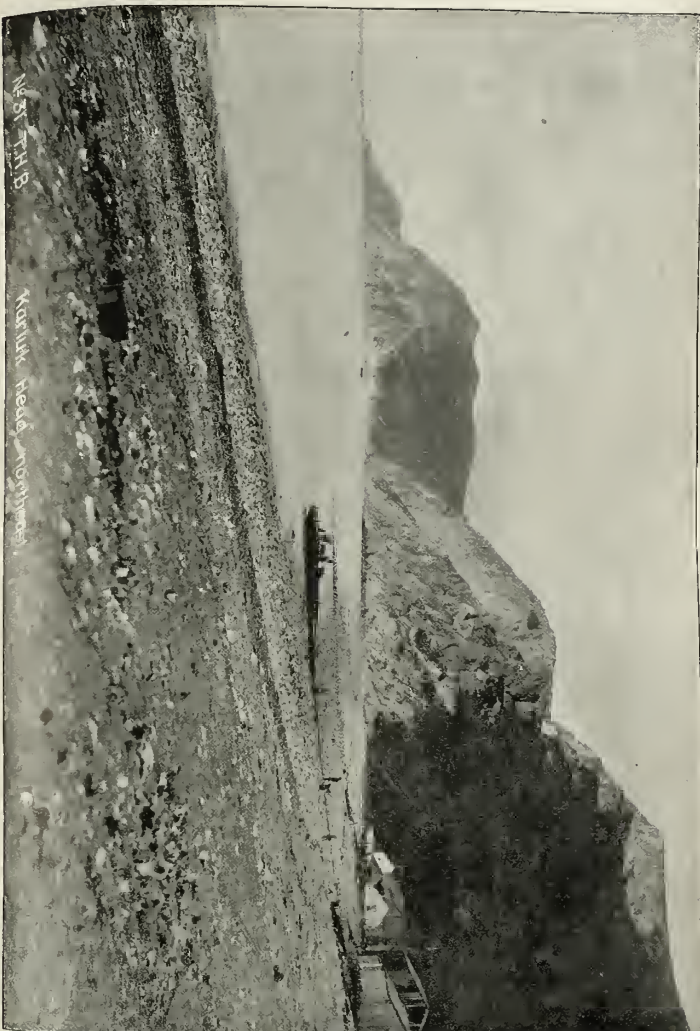
FIG. 11. CLARK'S TROUT (*Salmo purpuratus*). (See page 199.)

EXPLANATION OF PLATE L.

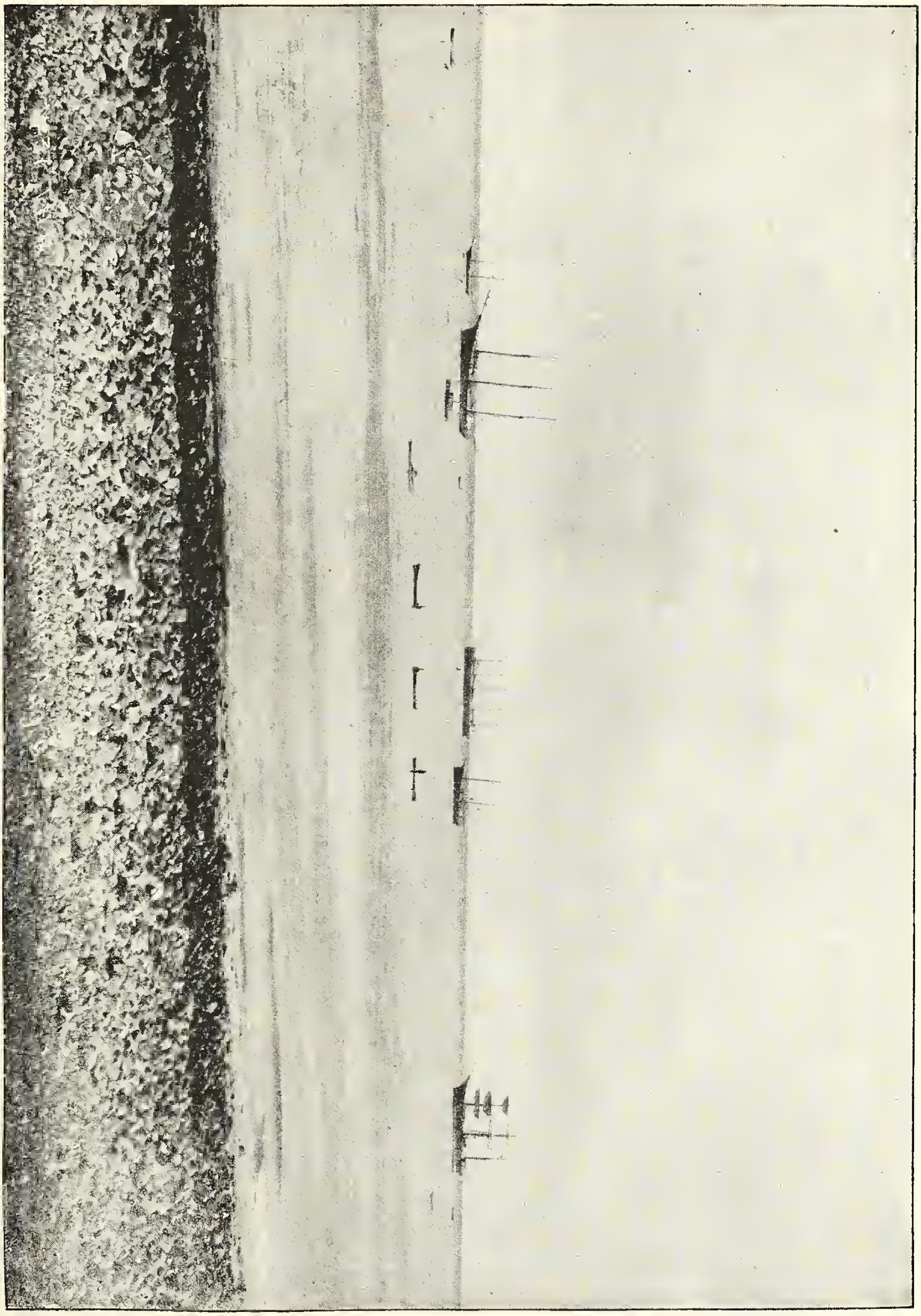
Karluk Head, or Cape Karluk, is one of the most striking headlands on the island of Kadiak because of its steep slope and the deep notch in its summit, by means of which its identification from sea is easy and certain. It is situated about one-half mile southwest of the mouth of Karluk River and has an elevation of about 1,600 feet. This cape, the highest part of a short spur, diminishes in height somewhat rapidly inland, and is separated from the Karluk River range by a low, level plateau, which, in the rainy season, carries on its surface an extensive shallow lake. The crescent-shaped beach limiting this plateau is made up of coarse pebbles and sand, and is a favorite seining ground for salmon.

PLATE L.

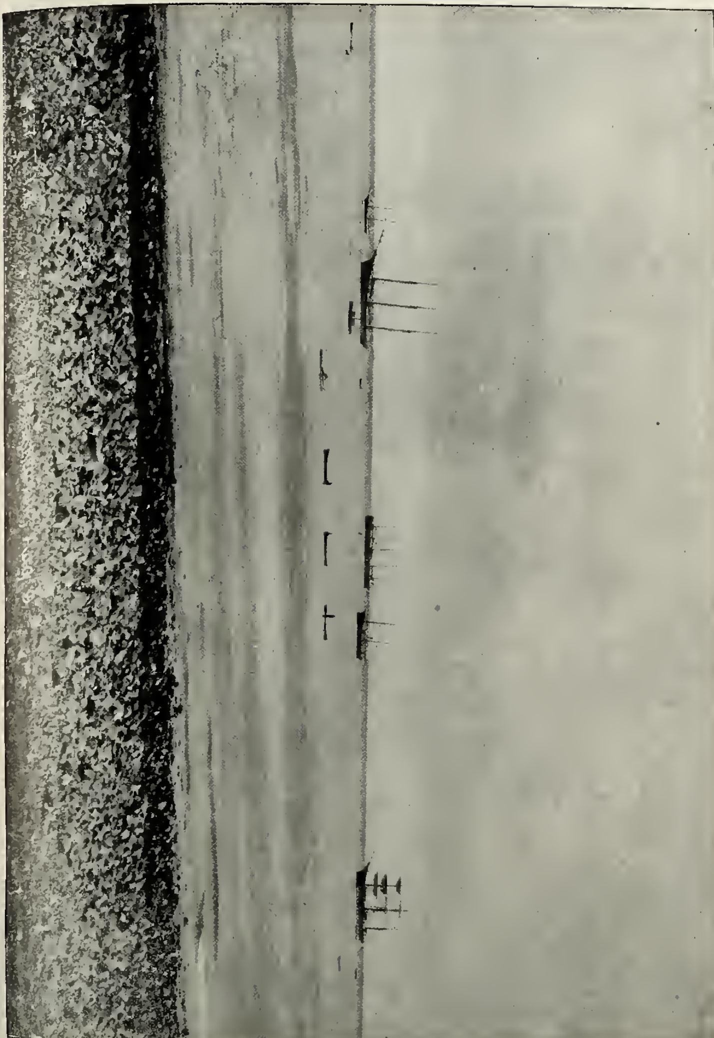
KARLUK HEAD, OR CAPE KARLUK. (See page 176.)



KARLUK CLIFFS FROM KARLUK, LOOKING NORTHEAST. (See page 176.)



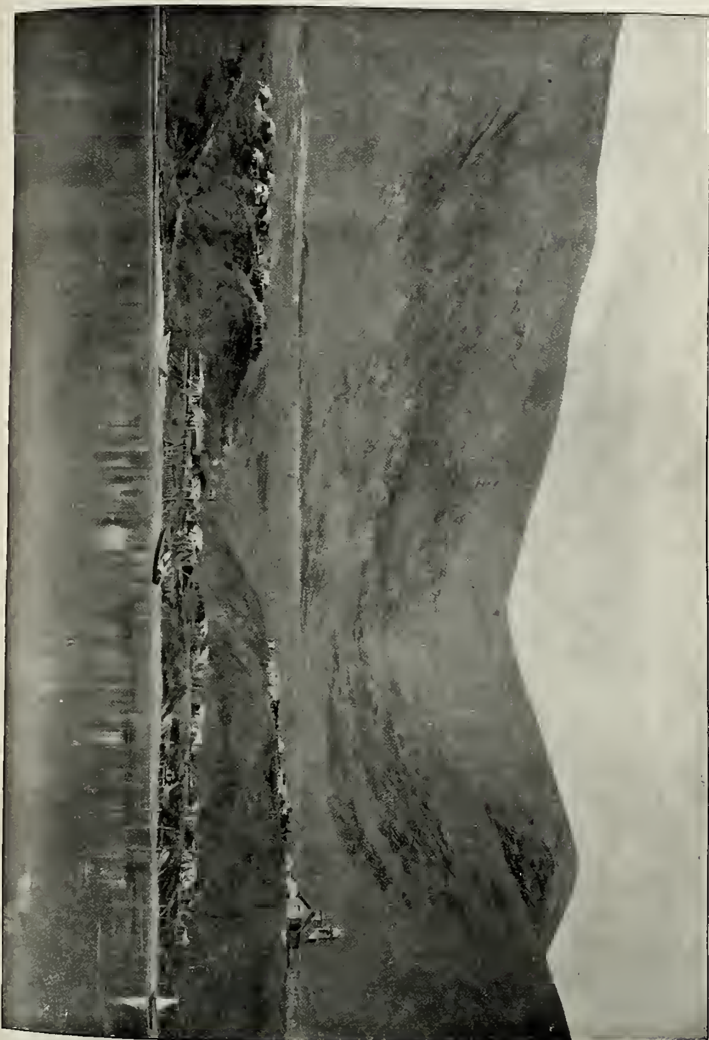
FLEET OF SALMON VESSELS IN KARLUK BAY, AUGUST 9, 1889. (See page 201.)



FLEET OF SALMON VESSELS IN KARLUK BAY, AUGUST 9, 1889. (See page 201.)

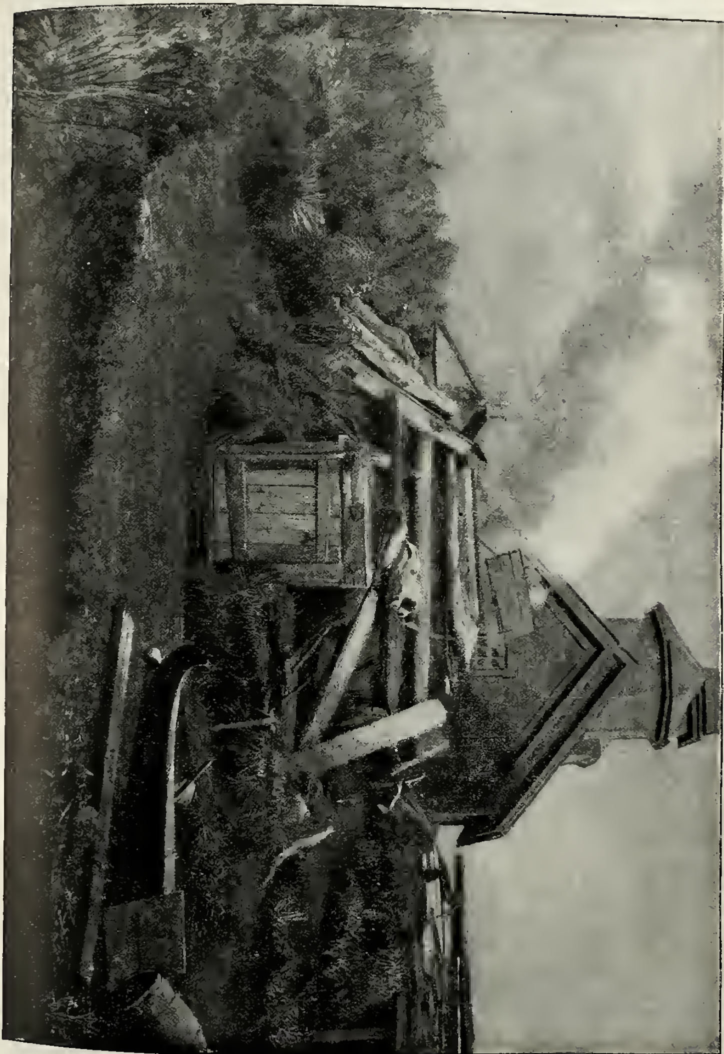
FLEET OF SALMON VESSELS IN KARLUK BAY, AUGUST 27, 1889. (See page 201.)

PLATE LV.



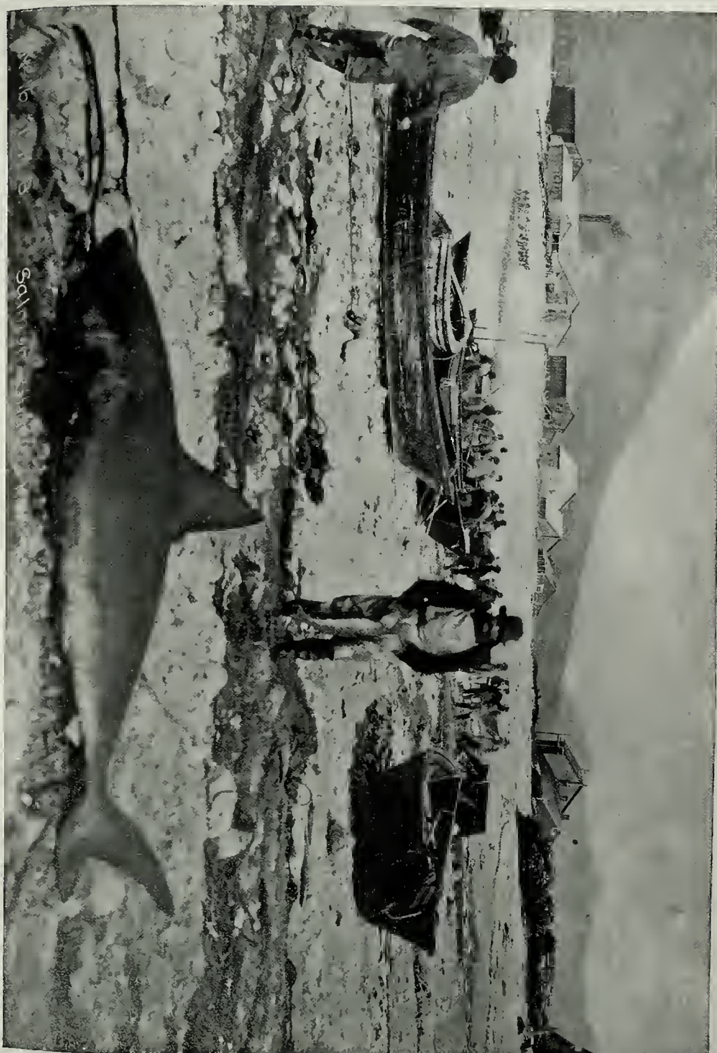
NATIVE VILLAGE, KARLUK, KADIAK ISLAND, ALASKA.

PLATE LVI.

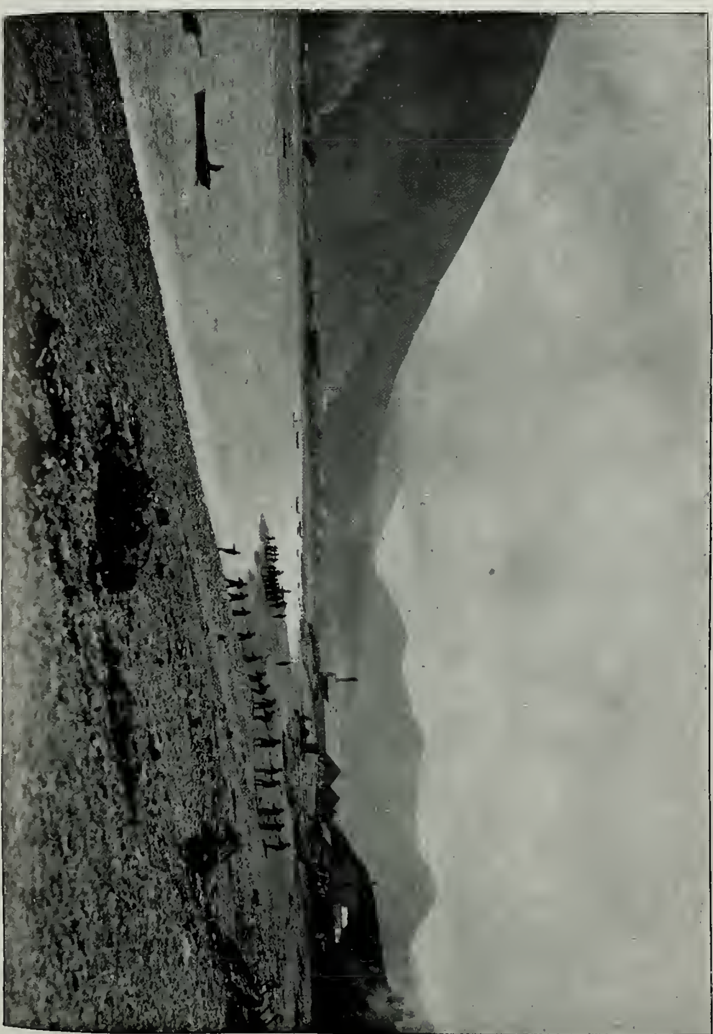


NATIVE DWELLING (BARABARA) AT KARLUK, KADIAK ISLAND, ALASKA. GREEK CHURCH IN BACKGROUND

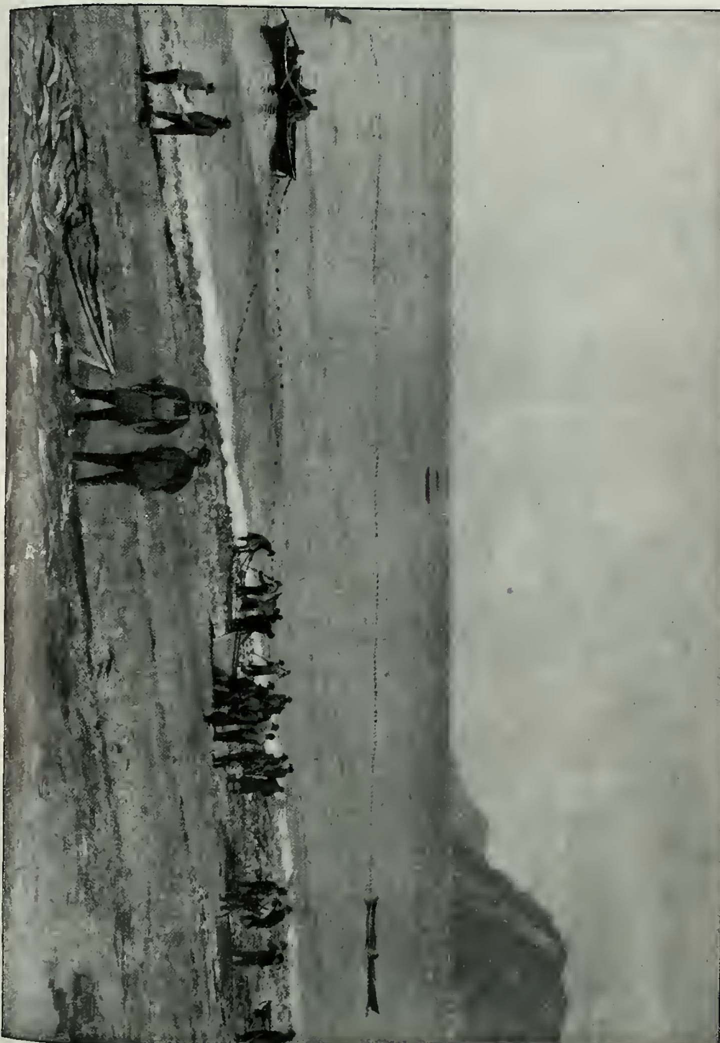
PLATE LVII.



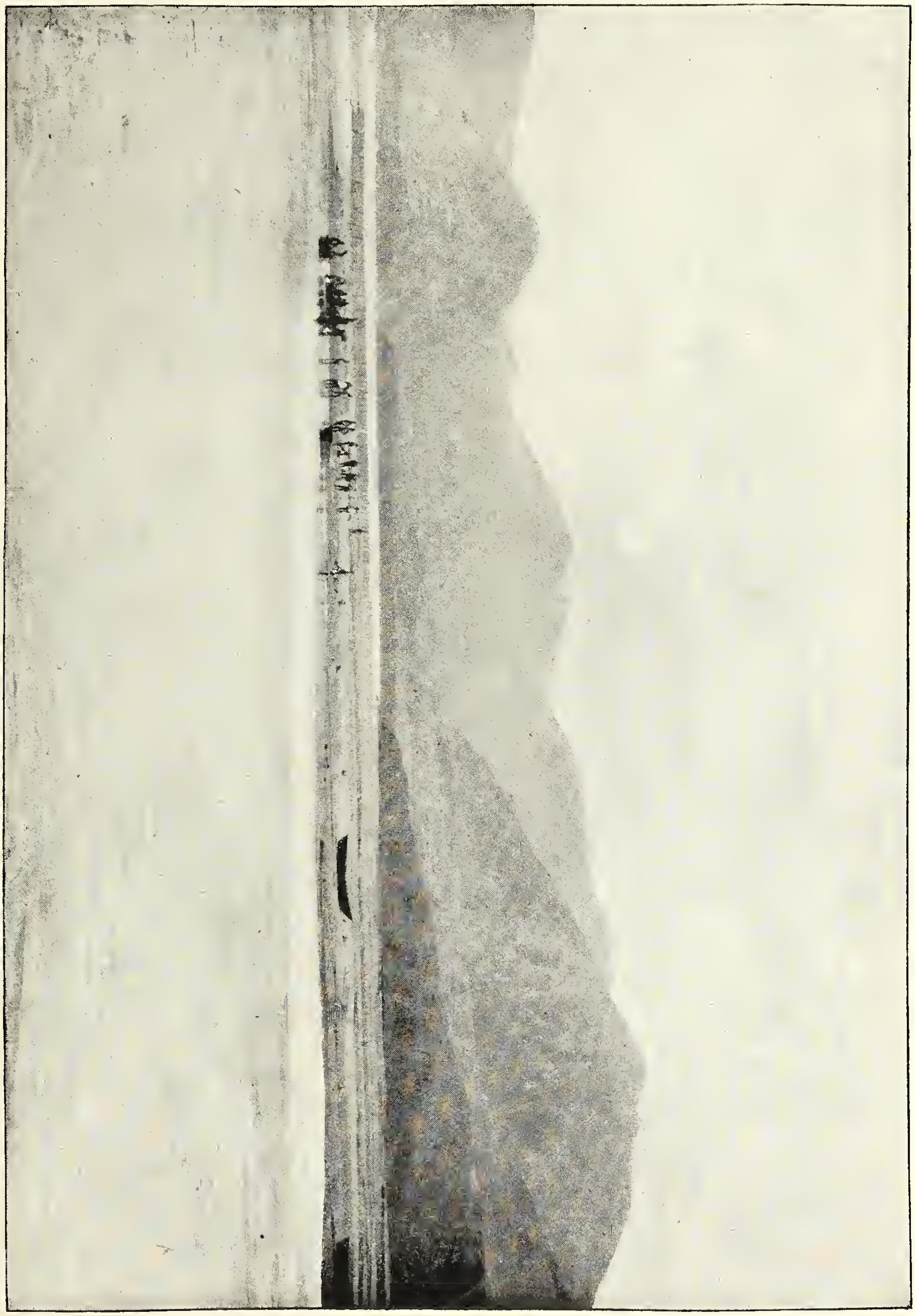
SEINING SALMON AT KARLUK, LOOKING EAST. PILING SALMON ON BEACH FOR TRANSFER TO CANNERIES. SALMON SHARK IN FOREGROUND. (See page 198.)



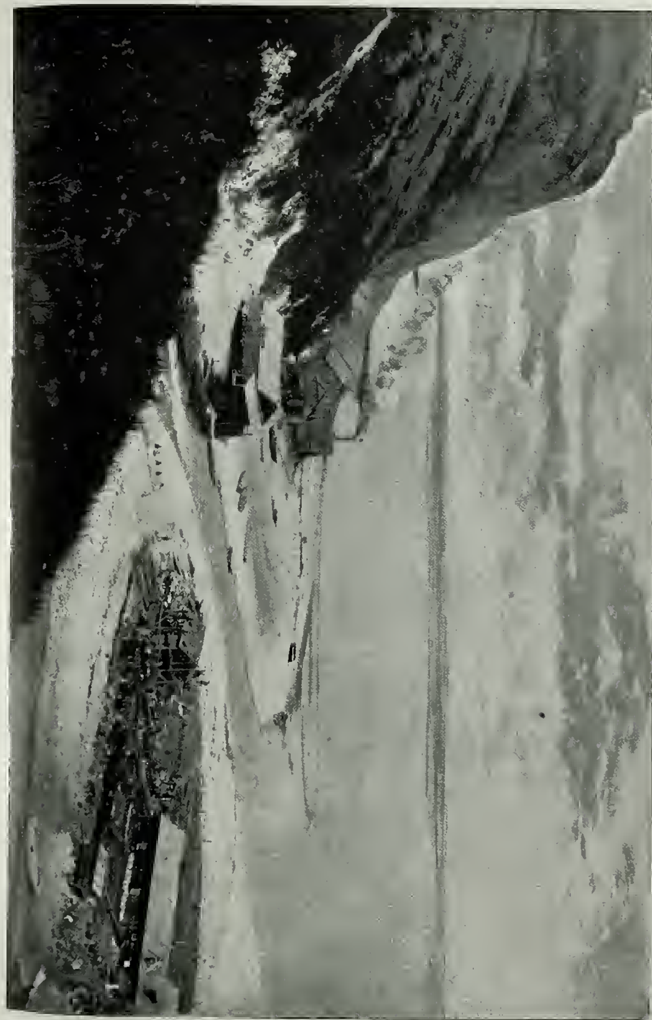
SEINING SALMON AT KARLUK, LOOKING EAST FROM BEACH NEARLY WEST OF ALASKA IMPROVEMENT COMPANY'S CANNERY.



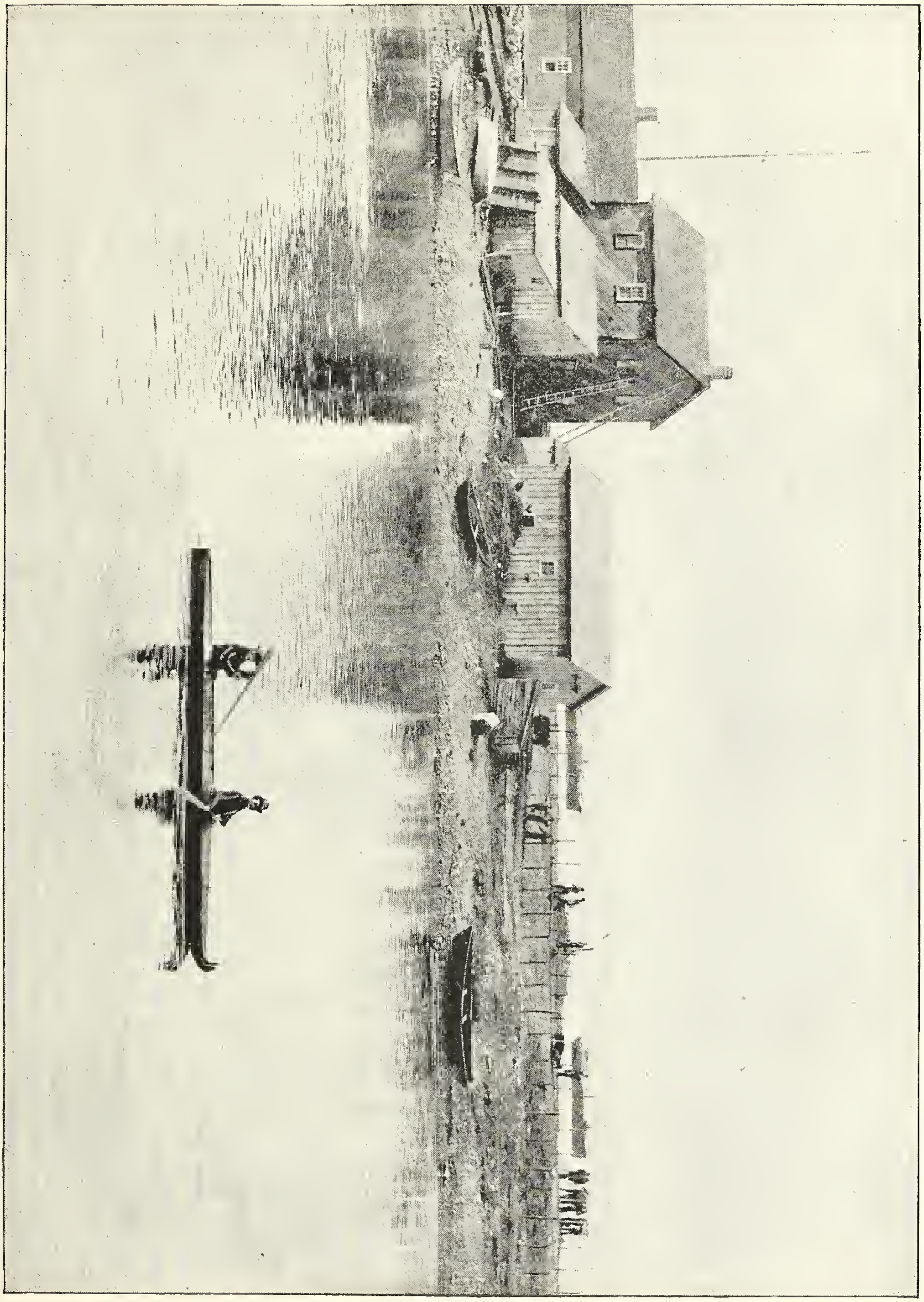
SEINING SALMON AT KARLUK: HAULING SEINE; PEWING FISH ON BEACH; HEAP OF 10,000 SALMON FROM ONE HAUL.



SEINING SALMON IN KARLUK RIVER. (See page 203.)

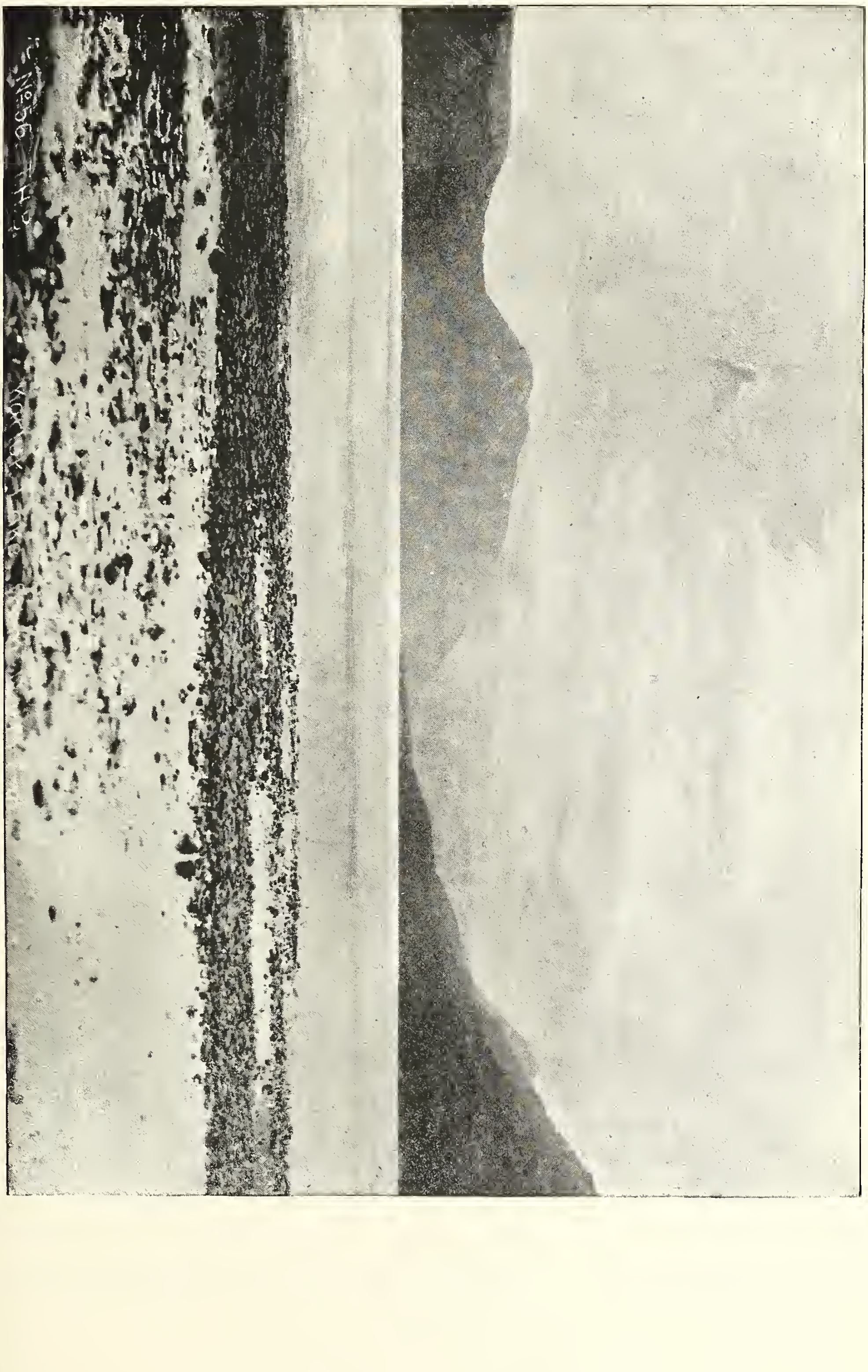


KARLUK RIVER MOUTH. CANNERY OF ALASKA IMPROVEMENT COMPANY. END OF KARLUK PENINSULA. (See page 176.)



KARLUK RIVER. BIDARKA WITH NATIVES. OFFICE OF KARLUK PACKING COMPANY. STEAMERS BERTHA AND HAYTIEN REPUBLIC.

PLATE LXIII.

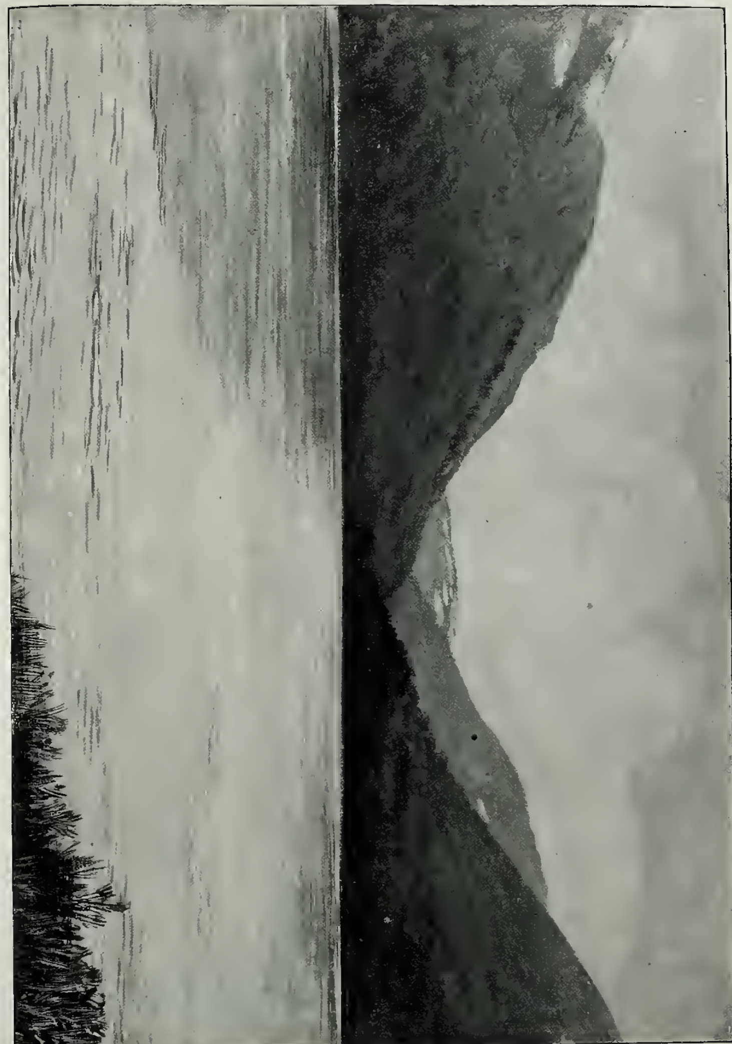


KARLUK LAKE, FROM NORTH END. (See page 179.)

PLATE LXIV.

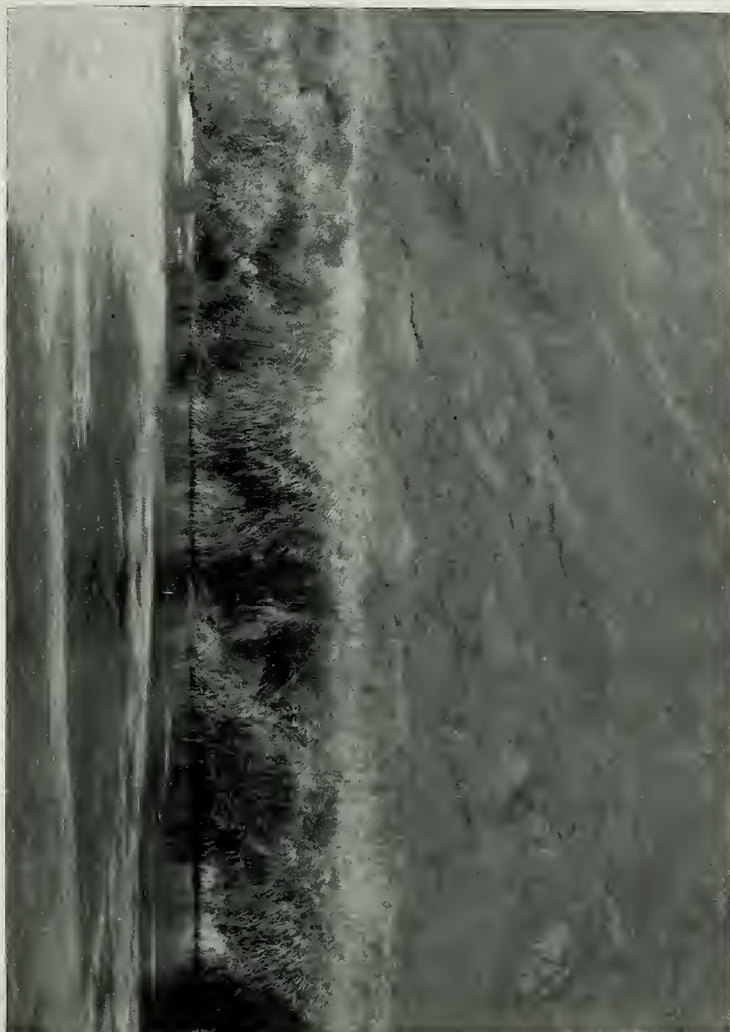
KARLUK LAKE, FROM SOUTH END. (See page 170.)

LAKE TRIBUTARY TO WEST ARM OF KARLUK LAKE. BREEDING GROUND OF RED SALMON. (See page 179.)

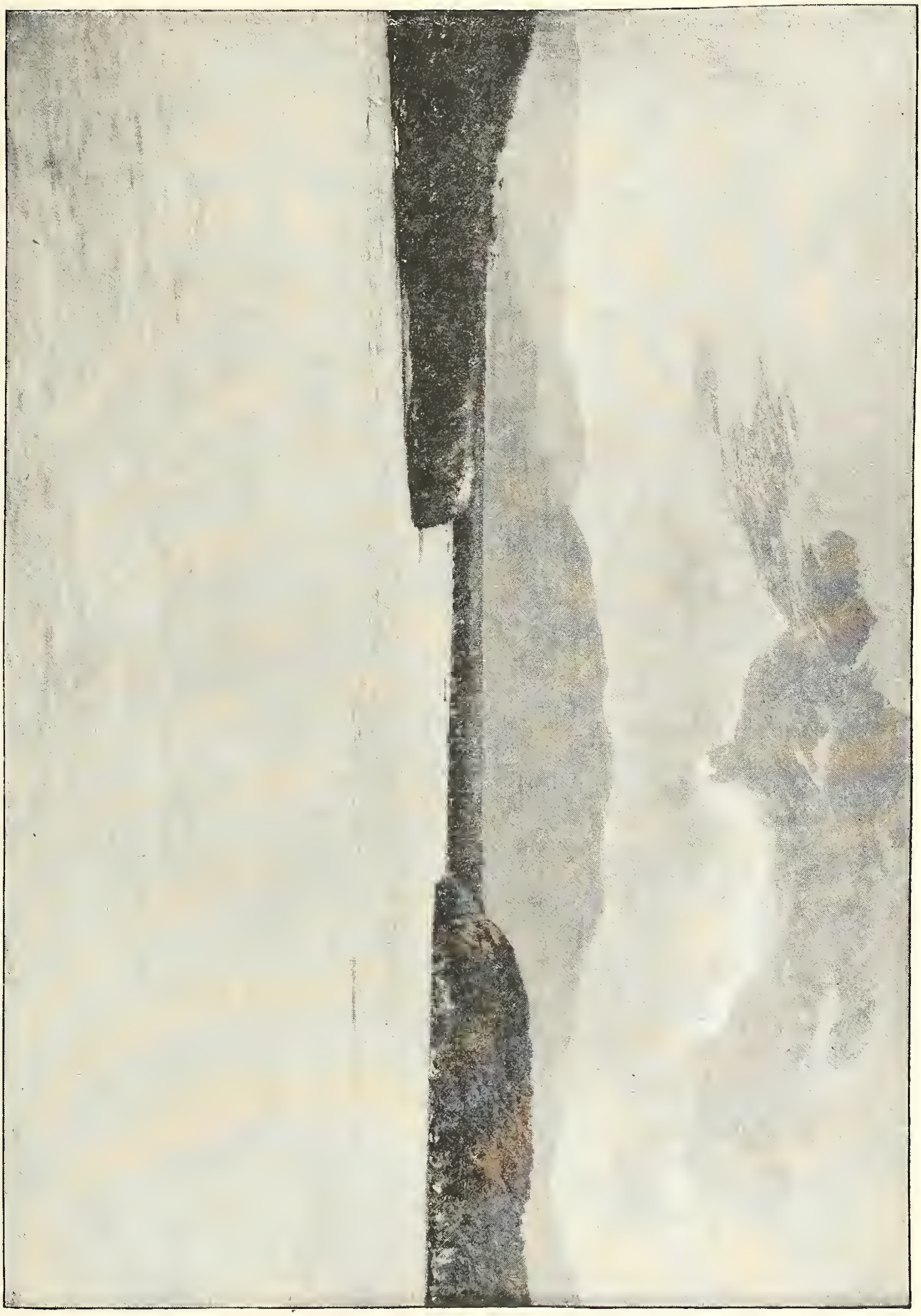


LAKE TRIBUTARY TO EAST ARM OF KARLUK LAKE. BREEDING GROUND OF RED SALMON. (See page 179.)

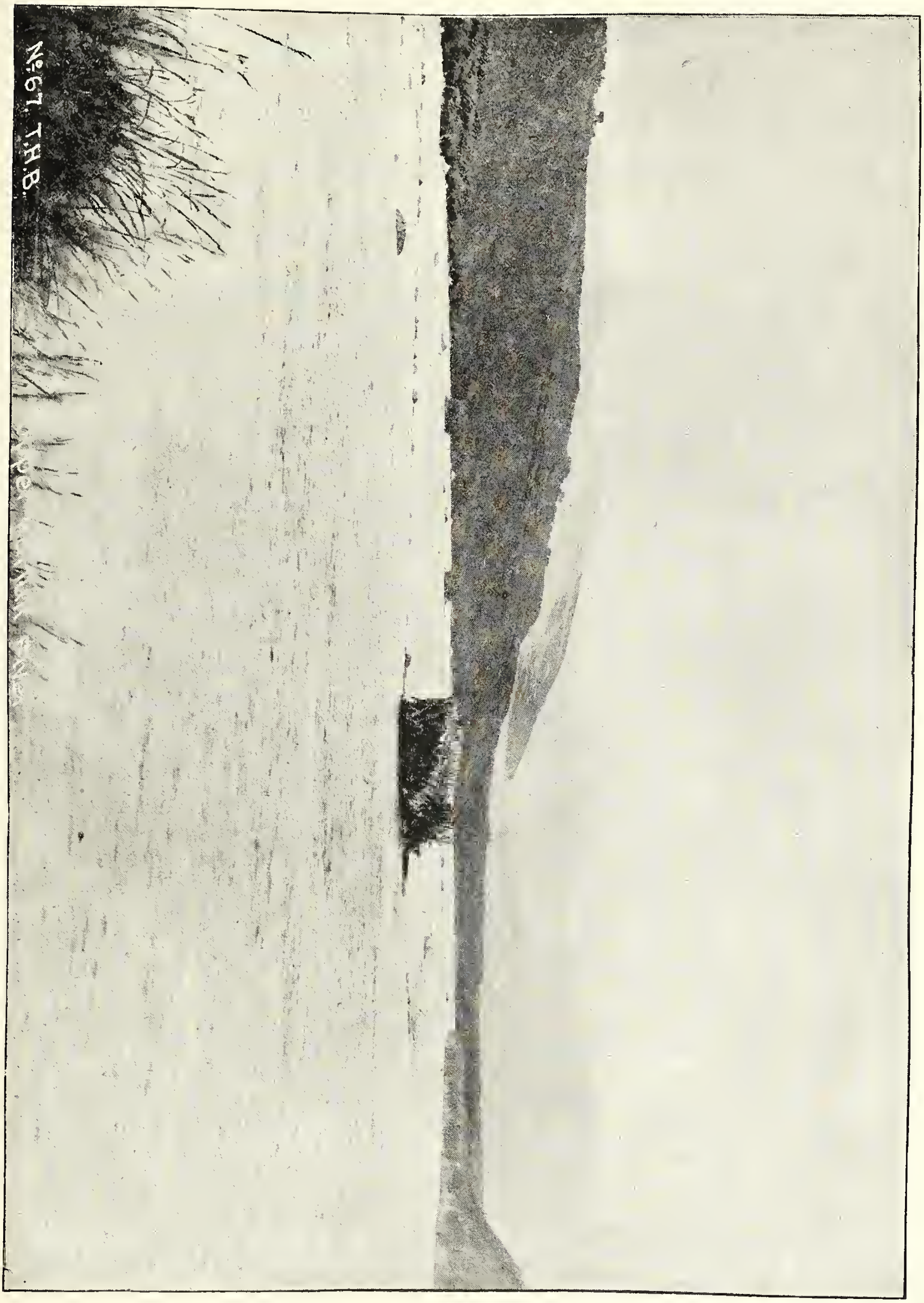
PLATE LXVII.



RIVER CONNECTING EAST ARM OF KARLUK LAKE WITH ITS TRIBUTARY LAKE. SALMON BREEDING GROUND. (See page 179.)



KARLUK RIVER SOURCE; KARLUK LAKE IN FOREGROUND. (See page 179.)

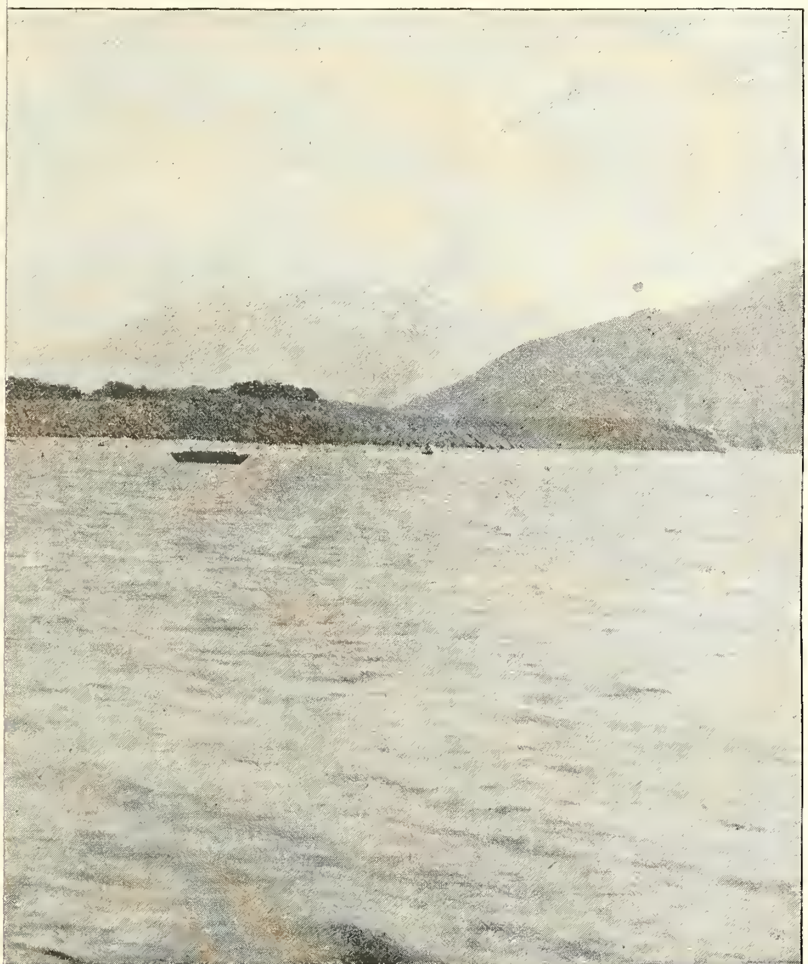


KARLUK RIVER NEAR ITS SOURCE, SHOWING LINES OF BOWLDERS UTILIZED IN BUILDING SALMON TRAPS.

SALMON FLEET IN UYAK BAY AUGUST 26 1889: STEAMER BERTHA, BARK CORYPHENE, STEAMERS ELLA ROHLFFS, HAYTIEN REPUBLIC, AND ALEUT.

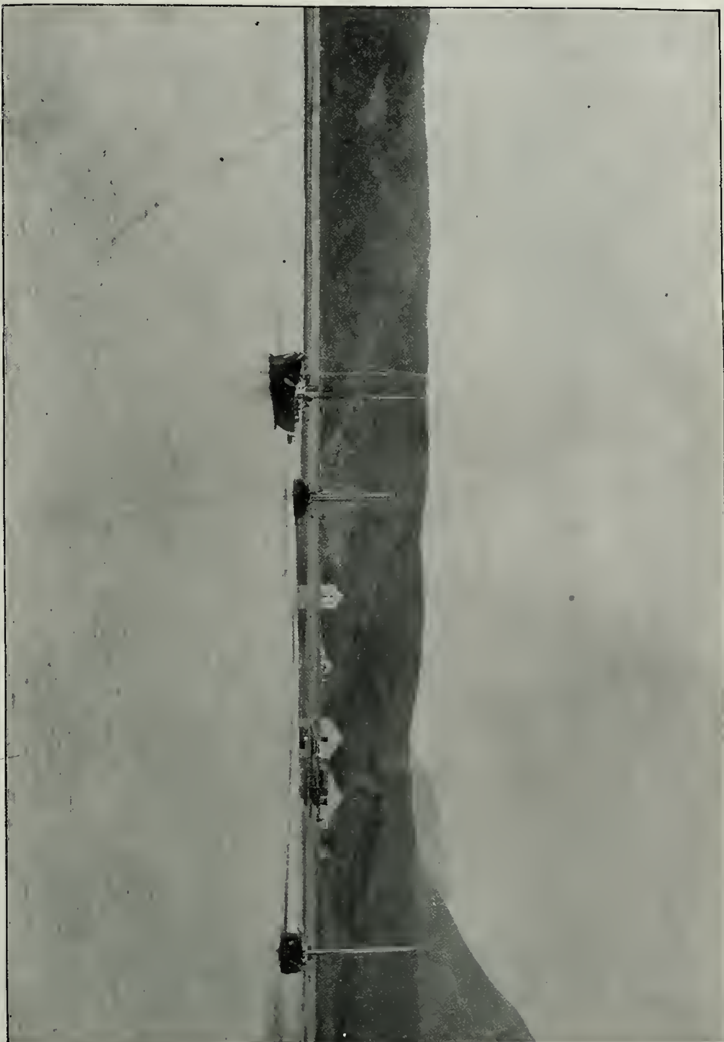
(See page 184.)

Plate LXXI.



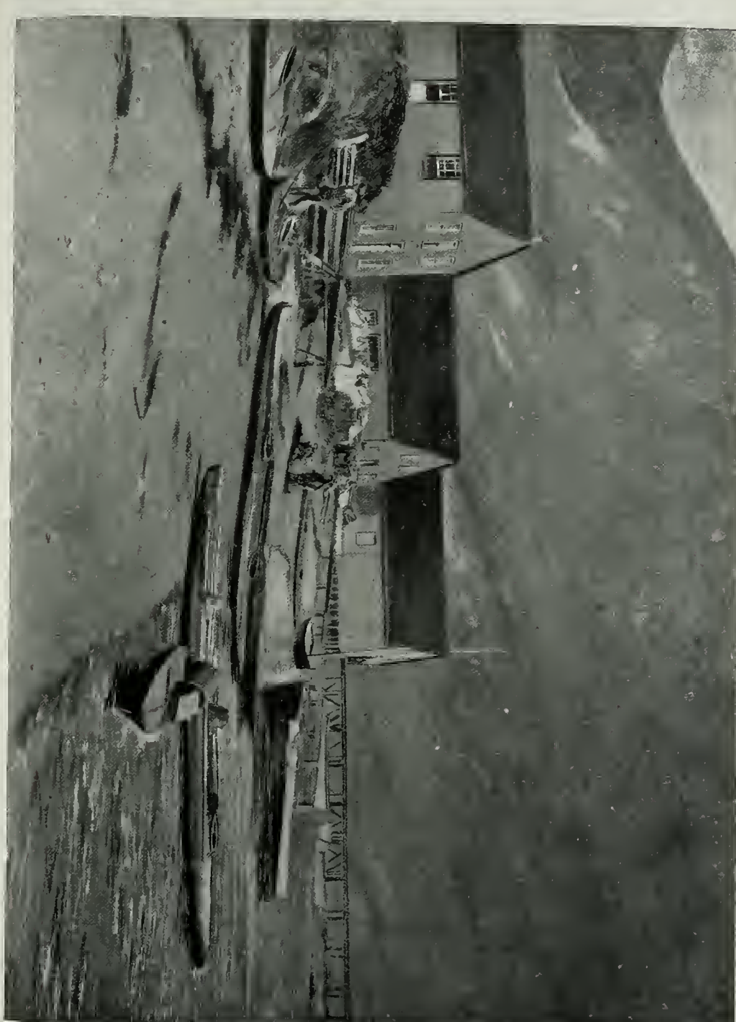
LARSEN'S COVE, UYAK BAY, AND CANNERY OF ARCTIC PACKING COMPANY. (See page 184.)

PLATE LXXII.



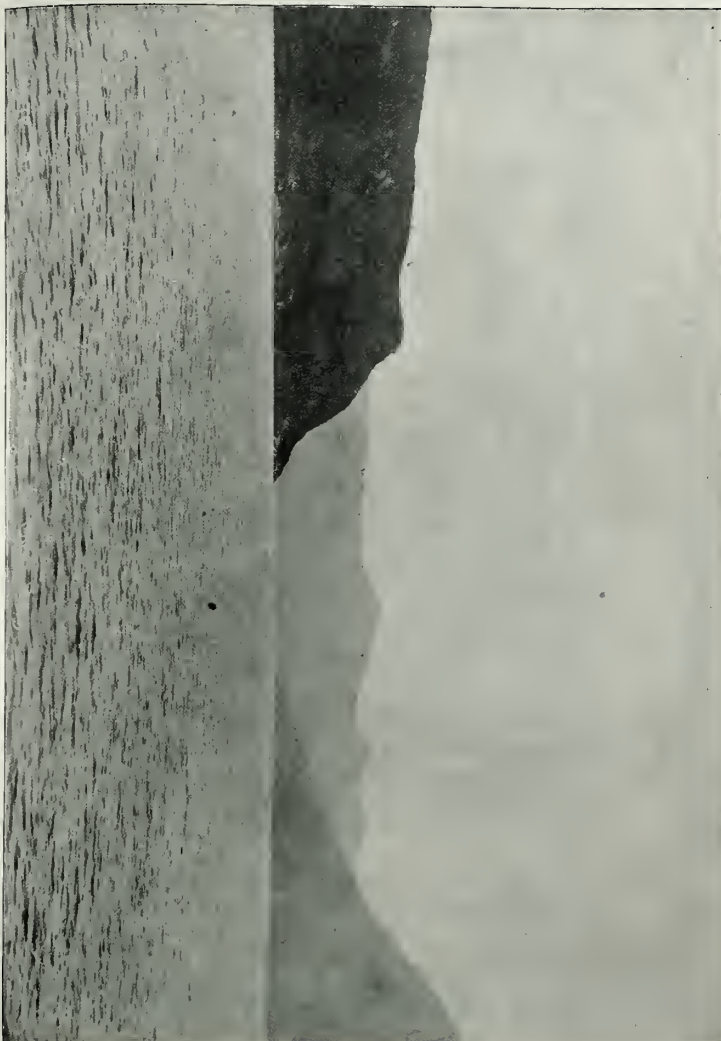
SNUG HARBOR, ALITAK BAY, CANNERY OF KODIAK PACKING COMPANY. (See page 184.)

PLATE LXXIII.



KODIAK PACKING COMPANY'S CANNERY, ALITAK BAY. NATIVE SKIN CANOES OR BIDARKAS. (See page 184.)

NARROWS IN ALITAK BAY, LOOKING SOUTHEAST, LEAST WIDTH ABOUT 100 FEET. (See page 188.)



ENTRANCE TO OLGA BAY FROM ALITAK BAY, LOOKING SOUTHWEST. (See page 182.)

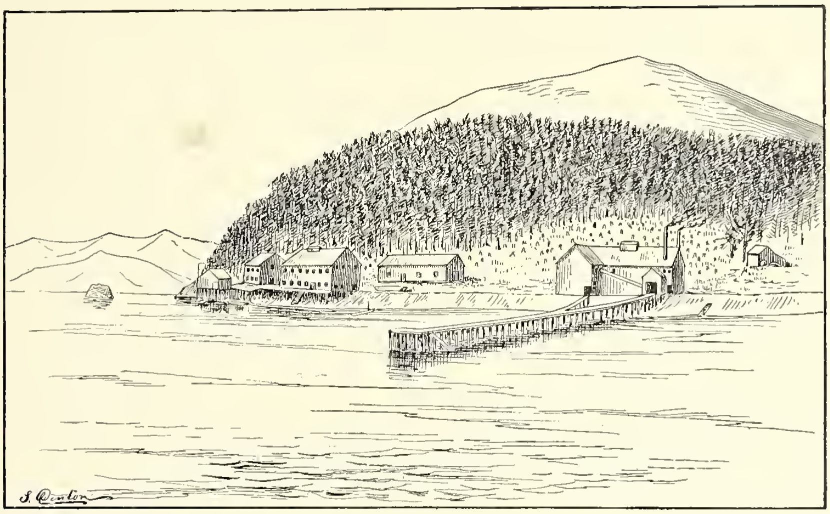
SALMON RIVER FALLING INTO OLGA BAY. OLD SALTING STATION AND NOW A CANNERY SITE. (See page 183.)

LAKE IN REAR OF THE STATION OF THE ALASKA COAST FISHING COMPANY, PORT HOBRON, SITKALIDAK ISLAND, KADIAK.

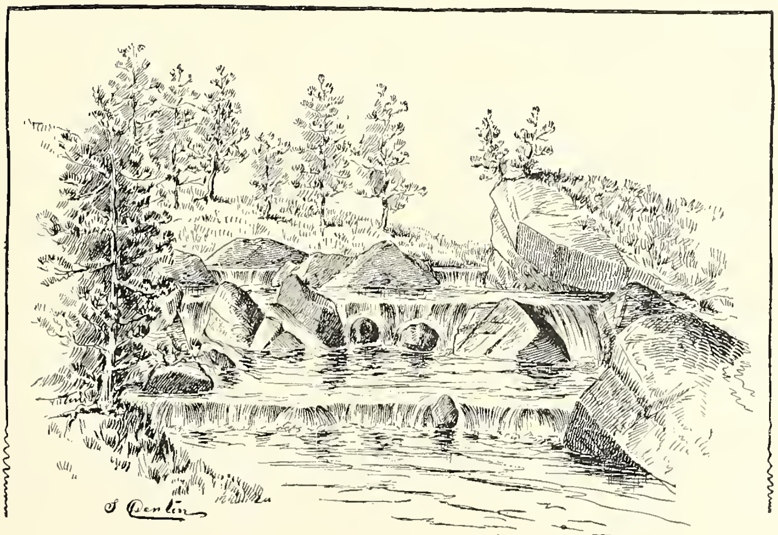
(Described in Bull. U. S. F. C., 1888, page 39.)

SALMON STATION OF THE ALASKA COAST FISHING COMPANY, PORT HOBRON, SITKALIDAK ISLAND, KADIAK.

(Described in Bull. U. S. F. C., 1888, page 39.)

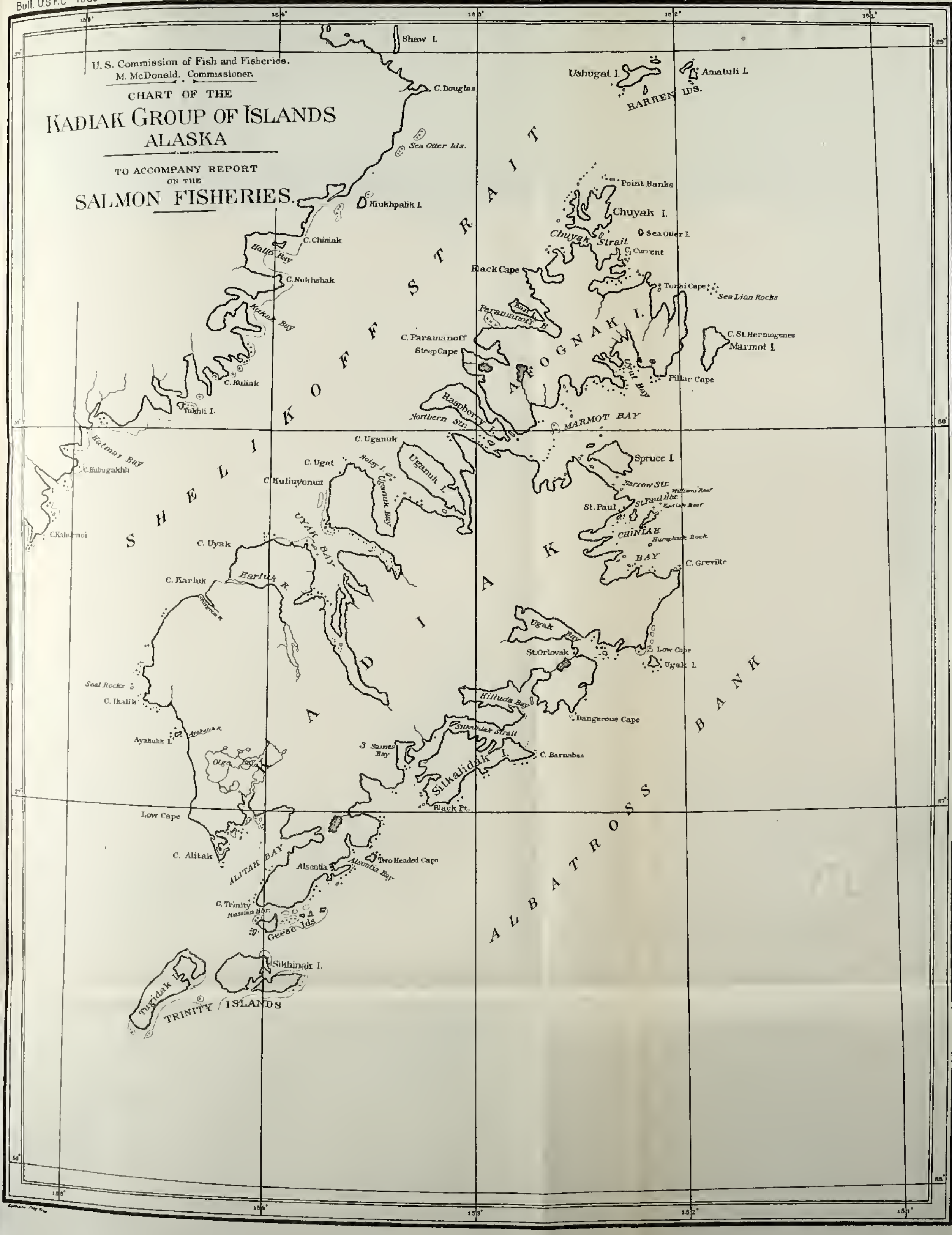


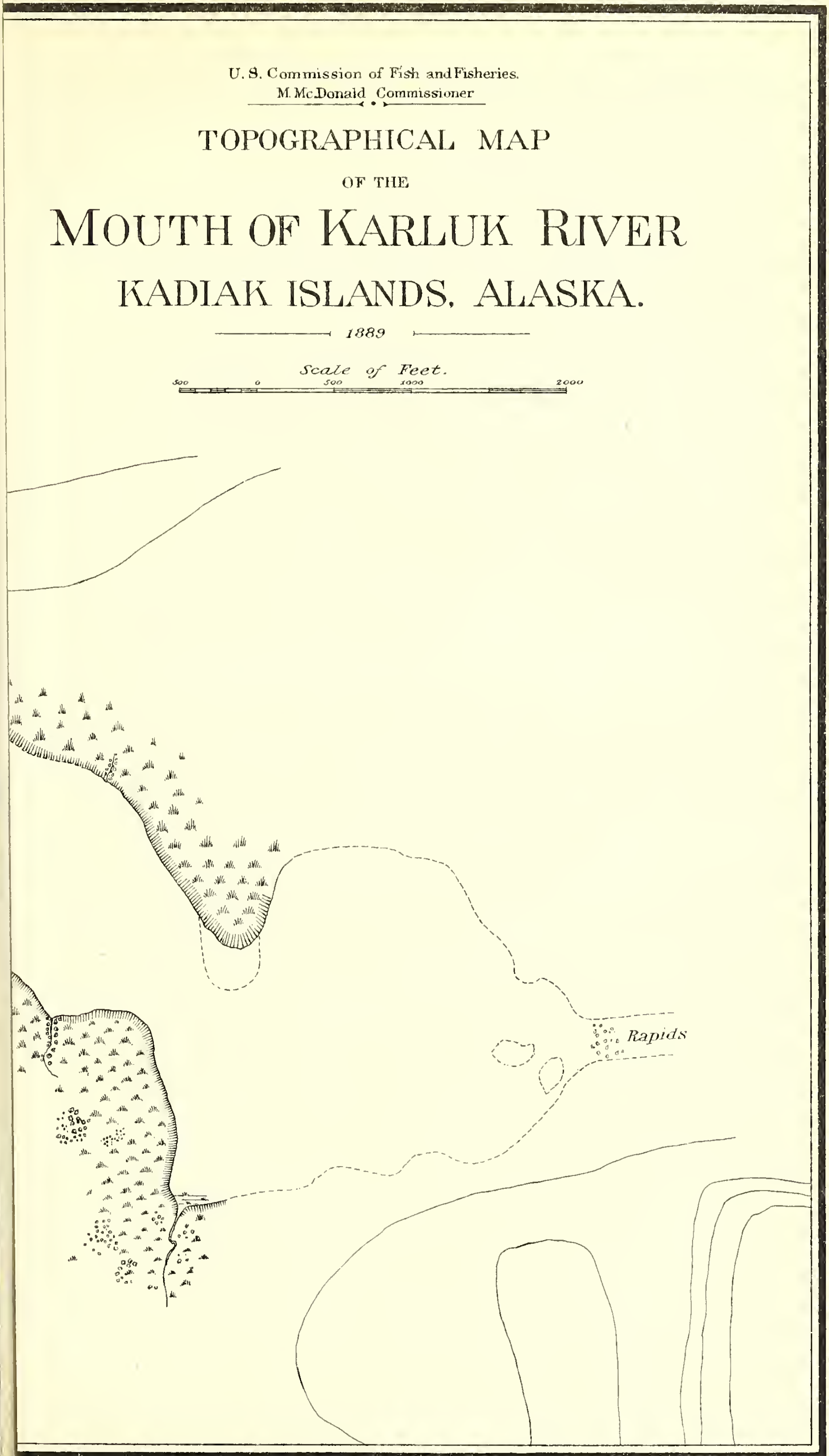
CANNERIES OF ROYAL PACKING COMPANY AND RUSSIAN AMERICAN PACKING COMPANY, AT AFOGNAK. (See page 185.)

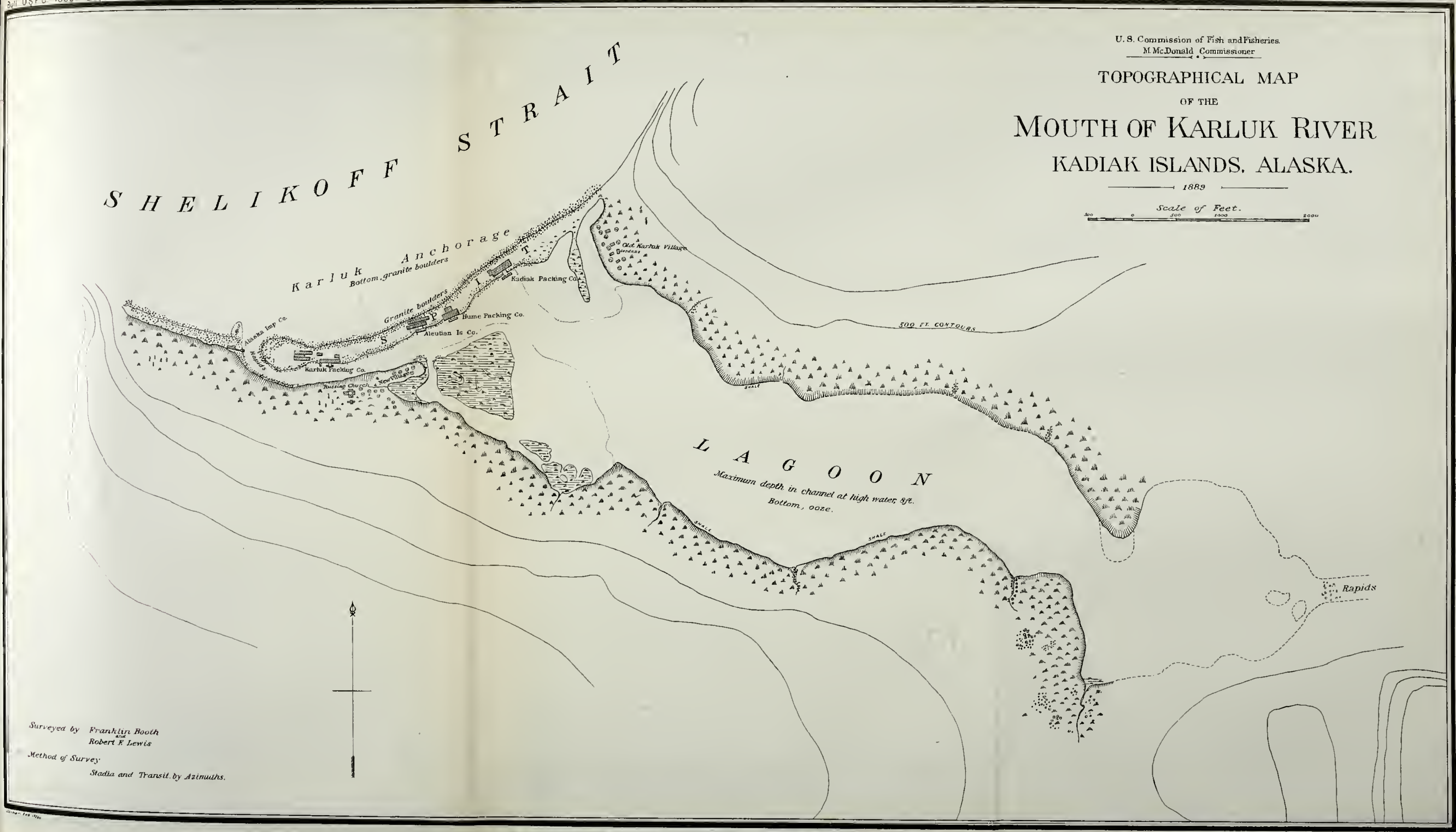


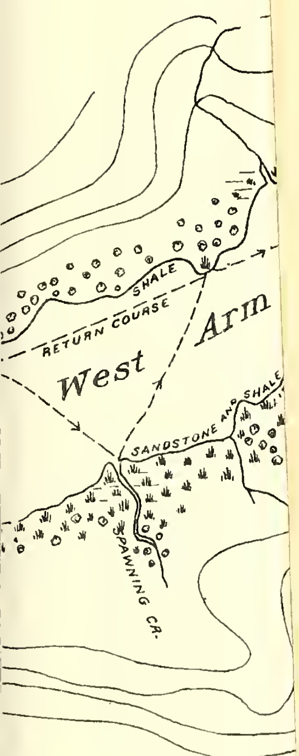
CASCADES IN AFOGNAK RIVER. (See page 185.)


59°
58°


U. S. Commission of Fish and Fisheries.
M. McDonald, Commissioner.
CHART OF THE
KADIAK GROUP OF ISLANDS
ALASKA
TO ACCOMPANY REPORT
ON THE
SALMON FISHERIES.
Shaw I.
C. Douglas
Ushugat I.
Amatuli I.
BARREN IDS.
Sea Otter Ids.
Point Banks
Kiukhpalik I.
Chuyak I.
Chuyak Strait
Sea Otter I.
C. Current
C. Chiniak
Hallo Bay
C. Nukhshak
Black Cape
Tonki Cape
Sea Lion Rocks
Kukak Bay
Paramanoff B.
AFOGNAK I.
C. St. Hermogenes
Marmot I.
C. Paramanoff
Steep Cape
C. Kuliak
Pillar Cape
Raspberry I.
Uganik Bay
Takhli I.
Northern Str.
MARMOT BAY
SHELIKOFF STRAIT
Katmai Bay
C. Kubugakhli
C. Uganuk
C. Ugat
Noisy I.
Uganuk I.
Uganik Bay
Spruce I.
C. Kuliuyonuit
Narrow Str.
Williams Reef
St. Paul
St. Paul Hbr.
Kadiak Reef
C. Kanuenoi
UYAK BAY
CHINIAK BAY
Humpback Rock
C. Uyak
C. Greville
C. Karluk
Karluk R.
Sturgeon R.
KADIAK
Ugak Bay
Low Cape
St. Orlovsk
Ugak I.
Seal Rocks
C. Ikalik
Kiliuda Bay
Dangerous Cape
Ayakulik R.
Ayakulik
Sitkalidak Strait
3 Saints Bay
C. Barnabas
Olga Bay
Sitkalidak I.
Black Pt.
Low Cape
C. Alitak
ALITAK BAY
Two Headed Cape
Alsentia
Alsentia Bay
C. Trinity
Russian Hbr.
Geese Ids.
Sikhinak I.
Tugidak I.
TRINITY ISLANDS
ALBATROSS BANK


U. S. Commission of Fish and Fisheries.
M. McDonald Commissioner
TOPOGRAPHICAL MAP
OF THE
MOUTH OF KARLUK RIVER
KADIAK ISLANDS, ALASKA.
1889
Scale of Feet.
500 0 500 1000 2000
Rapids


U. S. Commission of Fish and Fisheries.
M. McDonald Commissioner
TOPOGRAPHICAL MAP
OF THE
MOUTH OF KARLUK RIVER
KADIAK ISLANDS. ALASKA.
1889
Scale of Feet.
500 0 500 1000 2000
SHELIKOFF STRAIT
Karluk Anchorage
Bottom, granite boulders
Granite boulders
SPIT
Alaska Imp. Co.
Rapids
Karluk Packing Co.
Russian Church
New Village
Aleutian Is. Co.
Hume Packing Co.
Kadiak Packing Co.
Old Karluk Village
Gardens
500 FT. CONTOURS
SHALE
LAGOON
Maximum depth in channel at high water, 8ft.
Bottom, ooze.
SHALE
SHALE
Rapids
Surveyed by Franklin Booth and Robert F. Lewis
Method of Survey
Stadia and Transit, by Azimuths.

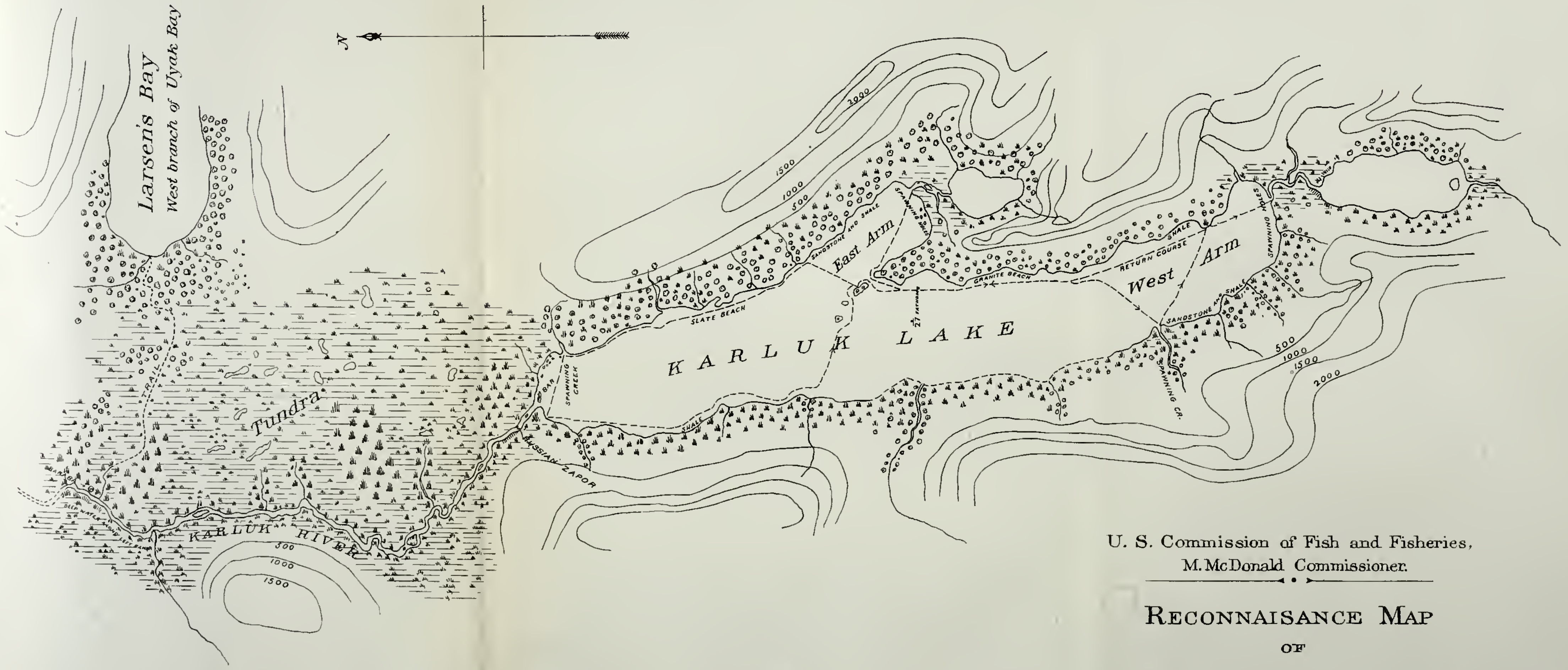


U. S. Commissic
M. McDo

RECONN

LAKE AND

Sca



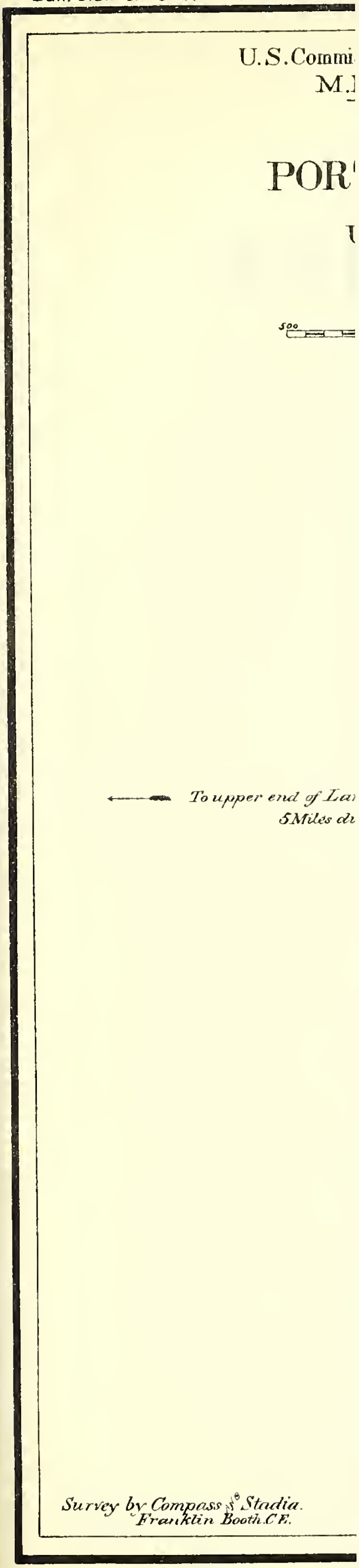
U. S. Commission of Fish and Fisheries,
M. McDonald Commissioner.

RECONNAISANCE MAP
OF
KARLUK LAKE AND PORTION OF KARLUK RIVER.

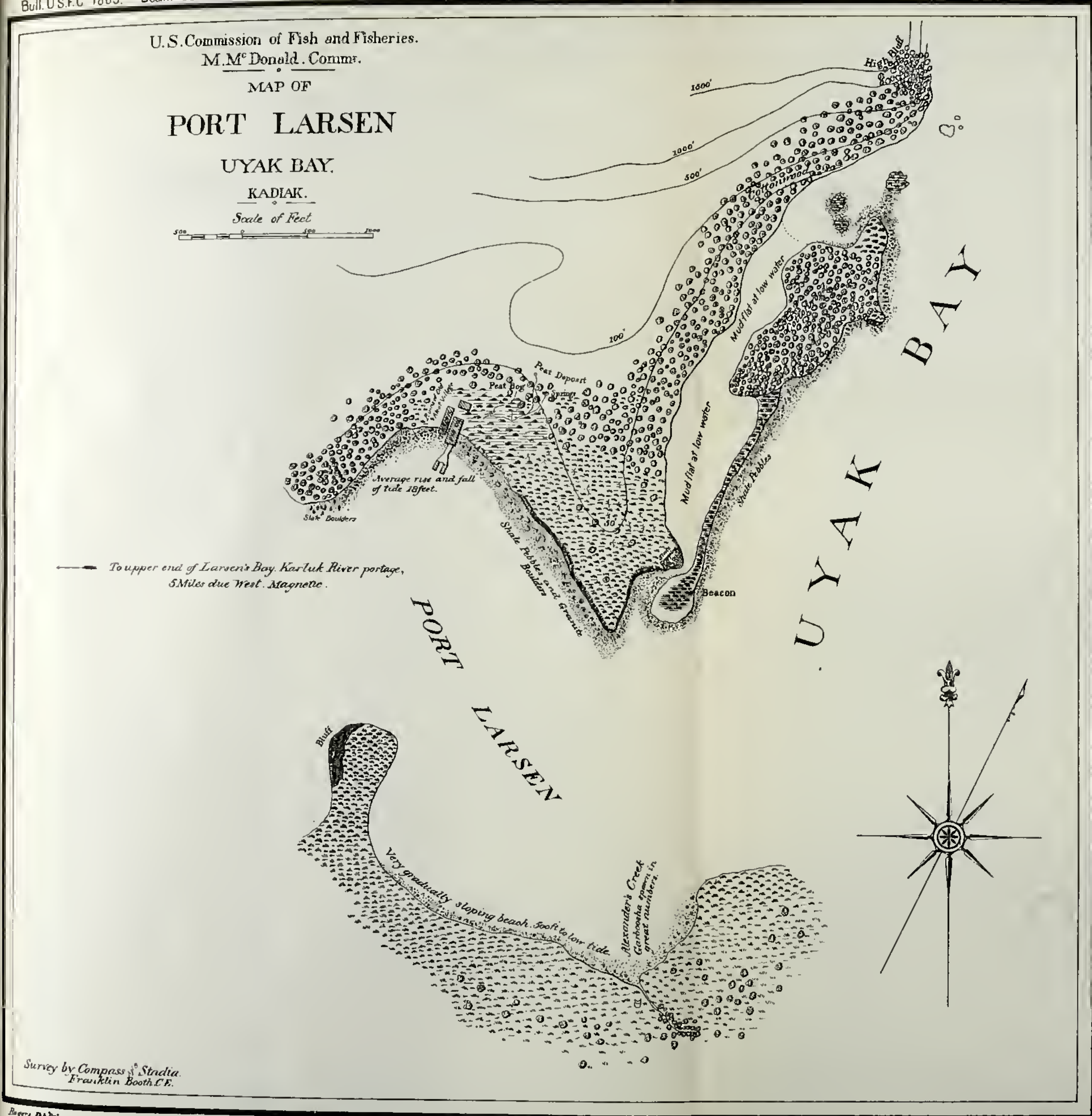
Scale of Miles

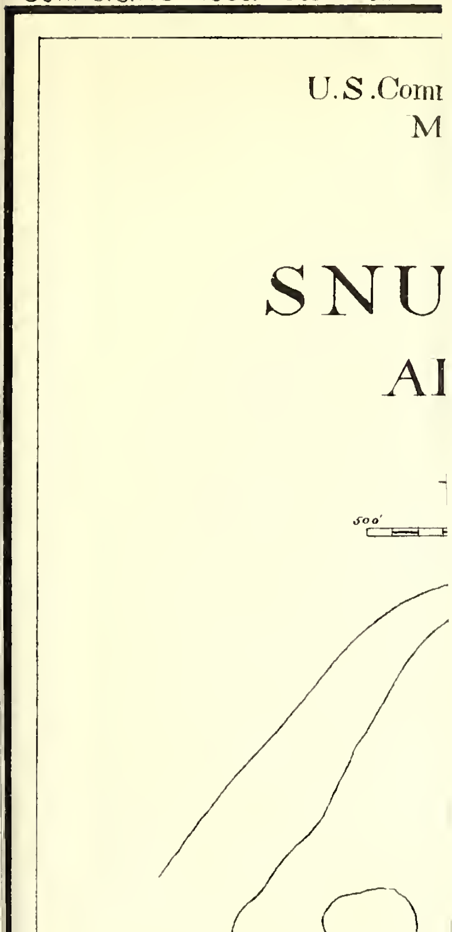
1 ½ 0 1 2 3

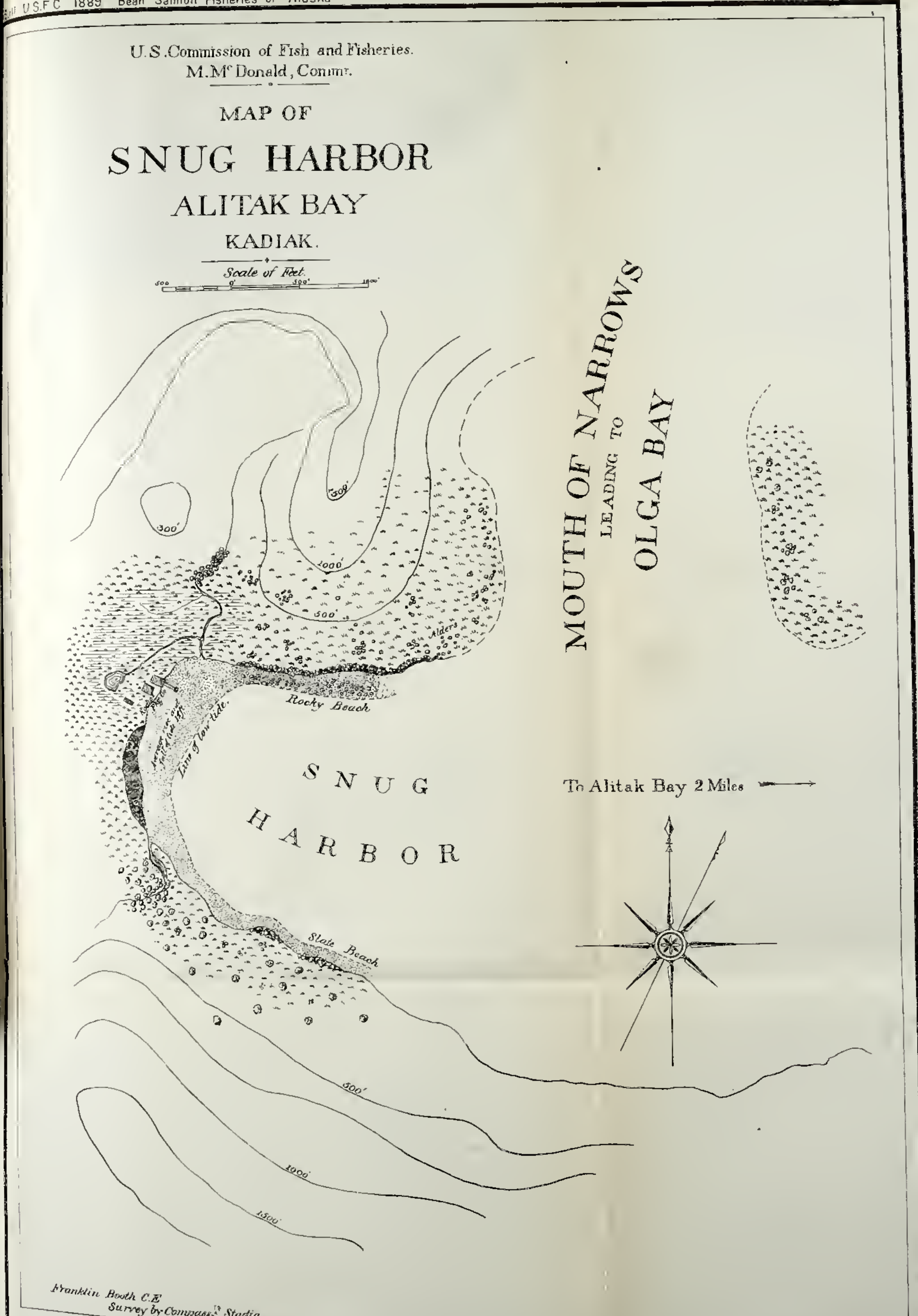
Gorham Feb. 14/90

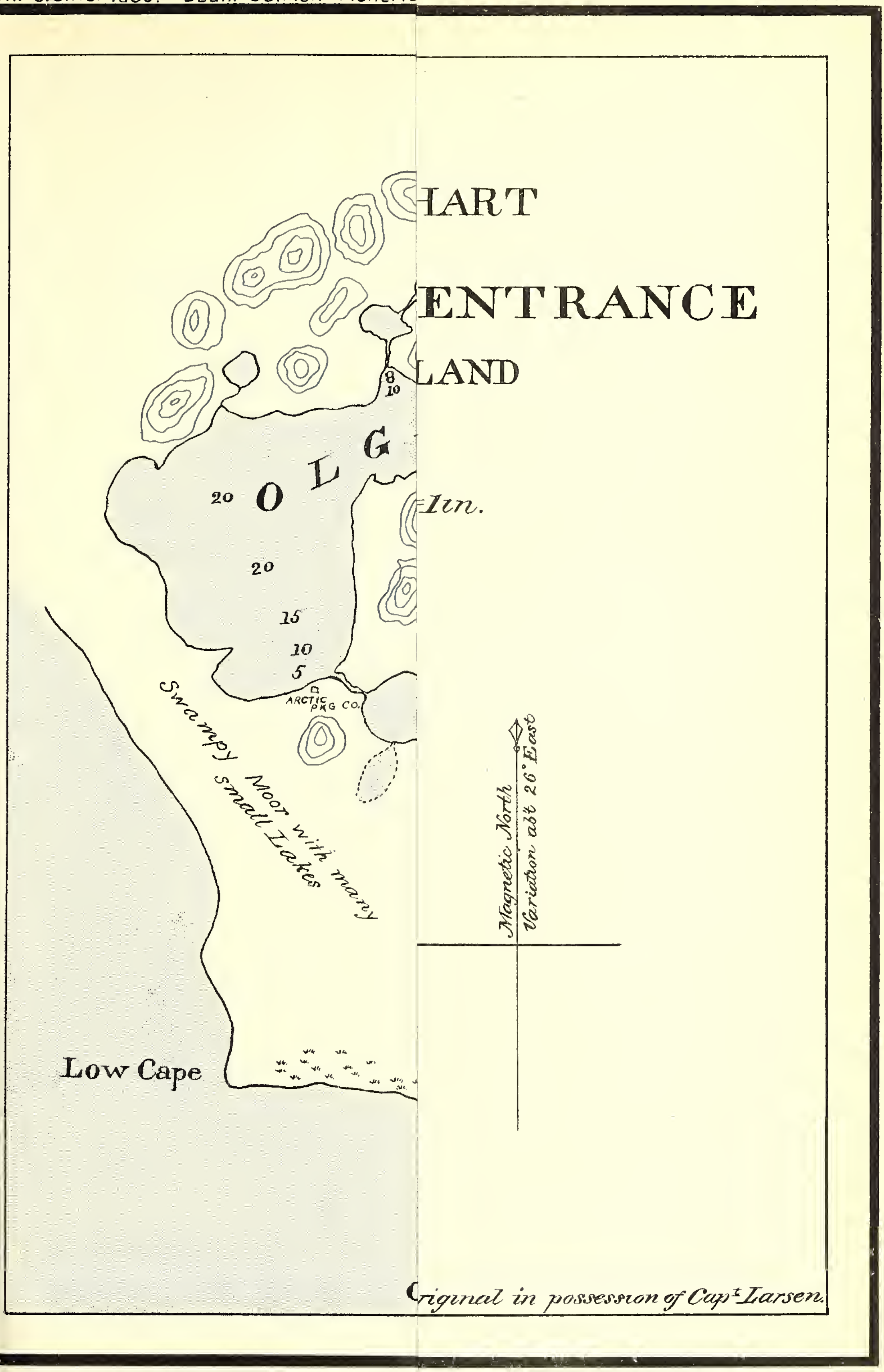


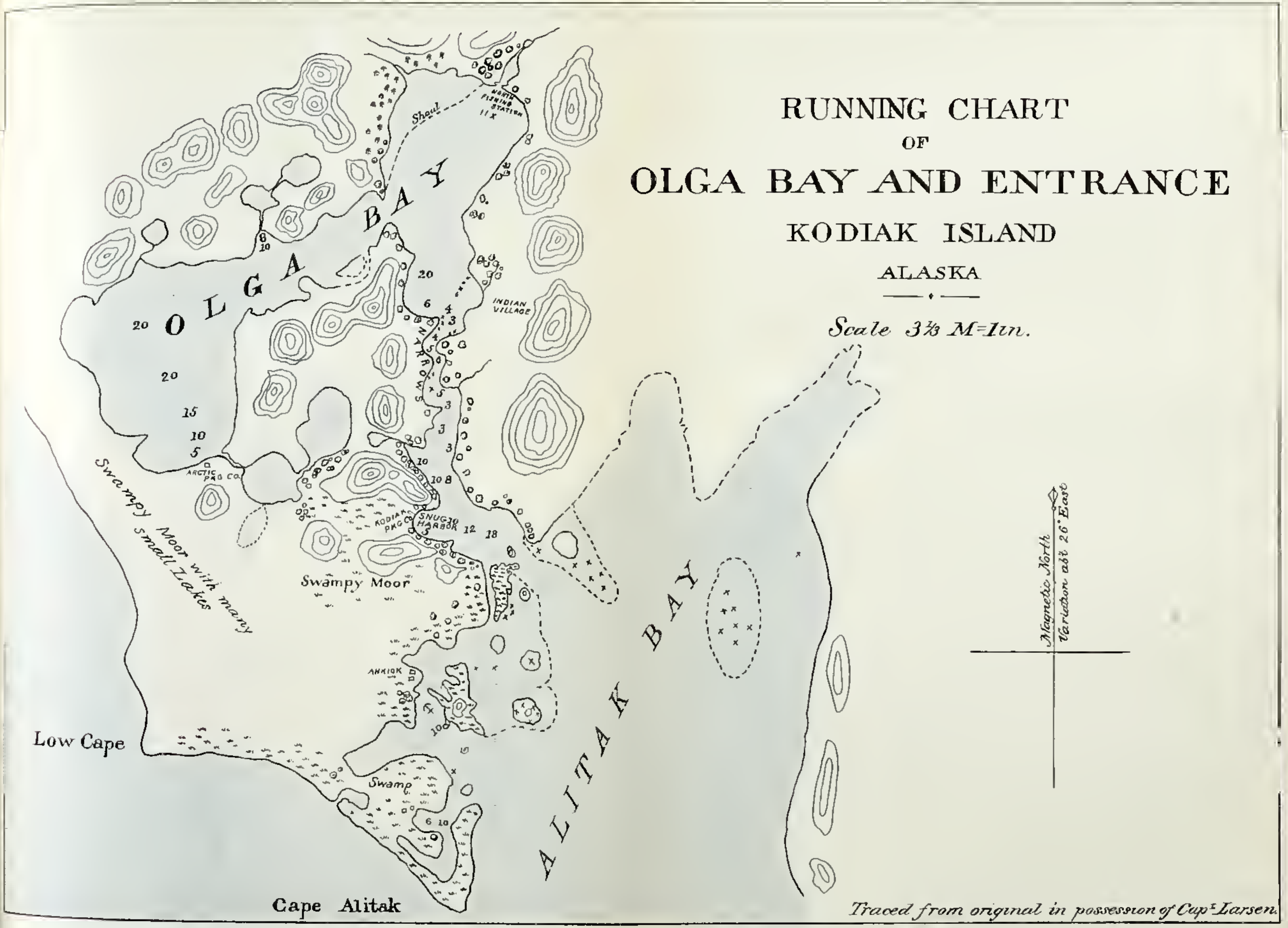
Rogers. Feb '90

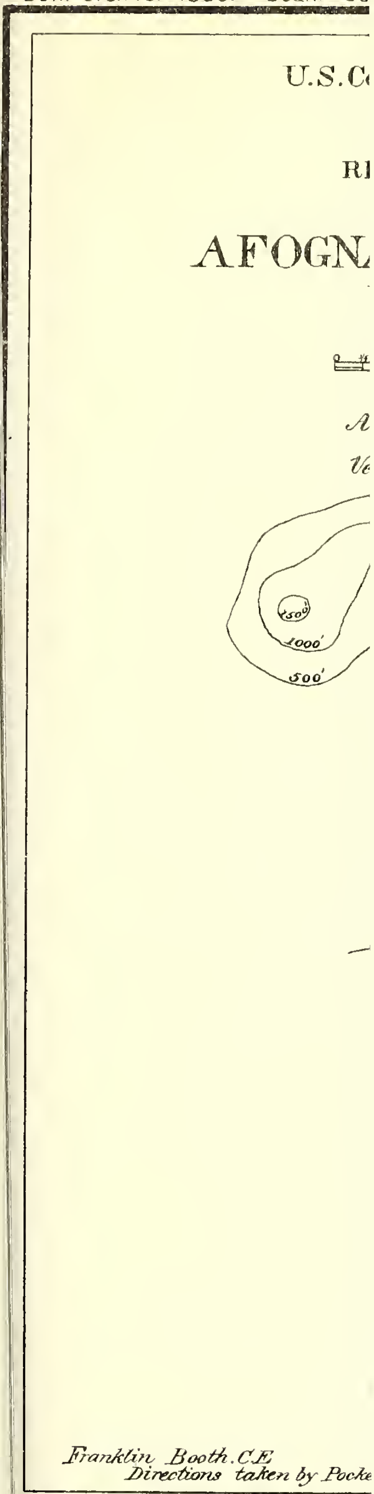

U.S. Commission of Fish and Fisheries.
M. McDonald. Commr.
MAP OF
PORT LARSEN
UYAK BAY.
KADIAK.
Scale of Feet
500 0 500 1000
High Bluff
1500'
1000'
500'
100'
Cottonwood
Mud flat at low water
Mud flat at low water
Peat Deposit
Peat Bog
Spring
Average rise and fall of tide 18 feet.
Slate Boulders
Shale Pebbles
Shale Pebbles and Granite Boulders
Beacon
UYAK BAY
To upper end of Larsen's Bay. Karluk River portage, 5 Miles due West. Magnetic.
PORT LARSEN
Bluff
Very gradually sloping beach. 500ft to low tide.
Alexander's Creek
Garboosha spawn in great numbers.
Survey by Compass & Stadia.
Franklin Booth C.E.


U.S.Comı
M
SNU
AI
500'

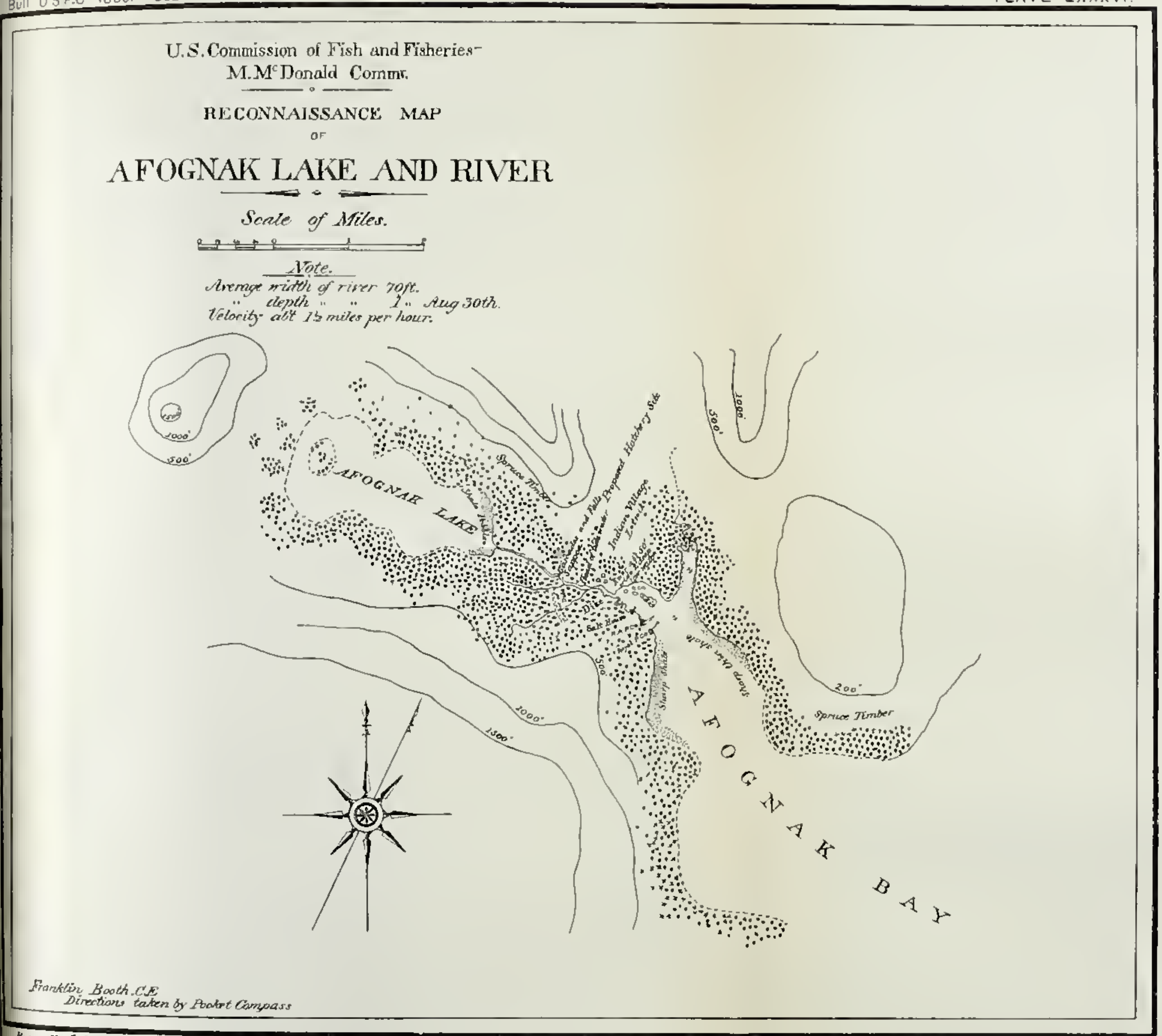

U.S. Commission of Fish and Fisheries.
M. McDonald, Commr.
MAP OF
SNUG HARBOR
ALITAK BAY
KADIAK.
Scale of Feet.
500 0' 500' 1000'
MOUTH OF NARROWS
LEADING TO
OLGA BAY
1500'
1000'
500'
300'
Alders
Rocky Beach
Line of low tide
SNUG
HARBOR
Slate Beach
To Alitak Bay 2 Miles
500'
1000'
1500'
Franklin Booth C.E.
Survey by Compass & Stadia.


HART
ENTRANCE
LAND
8
10
O L G
Mn.
20
20
15
10
5
ARCTIC PKG CO.
Swampy Moor with many small Lakes
Magnetic North
Variation abt 26° East
Low Cape
Original in possession of Capt Larsen.


RUNNING CHART
OF
OLGA BAY AND ENTRANCE
KODIAK ISLAND
ALASKA
Scale 3⅓ M=1in.
OLGA BAY
ALITAK BAY
Shoal
NORTH FISHING STATION
INDIAN VILLAGE
NARROWS
ARCTIC PKG CO.
KODIAK PKG CO.
SNUG HARBOR
Swampy Moor with many small Lakes
Swampy Moor
AKHIOK
Swamp
Low Cape
Cape Alitak
Magnetic North
Variation abt 26° East
Traced from original in possession of Capt. Larsen.



Rogers Feb '90"


U.S. Commission of Fish and Fisheries—
M. McDonald Commr.
RECONNAISSANCE MAP
OF
AFOGNAK LAKE AND RIVER
Scale of Miles.
Note.
Average width of river 70ft.
" depth " " 1 " Aug 30th.
Velocity abt 1½ miles per hour.
AFOGNAK LAKE
Spruce Timber
Proposed Hatchery Site
Indian Village
AFOGNAK BAY
Sharp Ohu shole
Spruce Timber
1000'
500'
200'
1000'
1500'
Franklin Booth C.E.
Directions taken by Pocket Compass
Rogers Feb '90


U. S. Commission of Fish and Fisheries,
M. McDonald, Commissioner.
MAP OF
ALASKA
SHOWING THE LOCATION
OF THE
SALMON CANNERIES
SEASON OF 1889
COMPILED FROM DATA FURNISHED BY
LIEUT. COMDR. HENRY E. NICHOLS U.S.N.
Base map copied from map of U.S. Coast and Geodetic Survey, published 1887.
ARCTIC OCEAN
EASTERN SIBERIA
BERING SEA
BERING STRAIT
NORTON SOUND
ARCTIC CIRCLE
KOTZEBUE SOUND
YUKON RIVER
Kuskokwim River
Alaskan Mountains
Rocky Mountains
Pelly River
Porcupine R.
Fort Yukon
INTERNATIONAL BOUNDARY
Mt. St. Elias
FAIRWEATHER GROUND
NORTH PACIFIC OCEAN
PORTLOCK BANK
BRISTOL BAY
ALIASKA PENA
KADIAK I.
Shelikoff St.
Cooks Inlet
KENAI PENA
PRIBILOFF IS.
St. Paul
St. George
St. Lawrence I.
Nunivak I.
Unimak
Unalashka I.
Shumagin Is.
Semidi Islands
DIXON ENTRANCE
POINT BARROW
Cape Lisburne
Pt. Hope
Icy Cape
Tanana R.
Noatak R.
Koyukuk River
Copper R.
Sushitna R.
Iliamna Lake
KULUKAK B.
KUSKOKWIM B.
4 CANNERIES
5 CANNERIES
3 CANNERIES
2 CANNERIES
1 CANNERY
Sitka
Juneau City
Fort Mumford
Stikine R.
Nass R.
Fort Simpson

13.—THE EMBRYOLOGY OF THE SEA BASS (SERRANUS ATRARIUS).

BY HENRY V. WILSON, PH. D.,
Assistant, U. S. Fish Commission.

(Plates LXXXVIII to CVII and 12 figures in text.)

INTRODUCTION.

The following paper, dealing with the embryology, forms part of a monograph on the Sea Bass in course of preparation under the direction of the United States Commissioner of Fisheries, Hon. Marshall McDonald. The monograph will contain, besides the embryology, a description of the larval development and of the adult fish, an account of the habits and distribution of the fry and the adult, and an account of the Bass viewed as a food-fish from an economic standpoint.

As might be inferred from its wide distribution along the Atlantic coast, all the way from Cape Cod to Florida, the Sea Bass is known under a variety of popular names. South of Cape Hatteras it is called Blackfish, in the Middle States "Black Will," "Black Harry," and "Hannahills." Sea Bass is the common name along the New England coast.*

My work on the bass was carried on at the Wood's Holl Station of the Fish Commission. It was begun in May, 1889, and has been continued without interruption to the present time. The bass makes its appearance in the neighborhood of Wood's Holl (Buzzard's Bay and Vineyard Sound) about the middle of May, and the spawning season lasts from that time until near the first of July. The fish is one of several (mackerel, scup, tautog, etc.), which at this season are reared in the hatchery of the Wood's Holl Station, and I was therefore able to obtain, with the least amount of trouble, as complete a set of material as could be desired. The collector, Mr. Vinal Edwards, visits the fish "pounds" in the neighborhood every morning at the time when the fish are taken out. Any fish that are found to be ripe are at once "spawned," *i. e.*, the eggs are pressed out into jars of sea water, with which milt is then mixed. The eggs thus fertilized are brought as quickly as possible to the hatchery and are placed in "tidal" jars or boxes, in which the water alternately rises and falls. The eggs during most of the period of incubation float at the surface of the water, but, as in the case of some other species of fish, there is a short period of time, not long before hatching, when they sink as though they were dead. The specific gravity,

* The Fisheries and Fishery Industries of the United States, Section I, 1884, p. 407.

however, again becomes less, and the eggs once more rise to the surface. Not all of the eggs suffer this change in specific gravity. In the batch from which my material was taken not more than two-thirds sank, the time being about forty hours after fertilization.

My material was obtained in the first days of June, when the temperature of the water was 60° F. The time from fertilization to hatching was about seventy-five hours. Later in the month, of course, the time was considerably less. The percentage of fish hatched out was very large, and for three or four days after hatching the young fish kept in aquaria remained in good health. By that time the yolksac had almost entirely disappeared, and the now very active fry evidently needed more spacious and varied quarters, for they began to die at a great rate.

In sectioning I found that the eggs killed in Perenyi's fluid, both old and young stages, yielded the best results. The yolk never becomes hard, but is coagulated, and especially in the young stages (segmentation and formation of the periblast) contracts away from the blastoderm, which it is therefore easy to separate from the yolk by means of needles.

After the body of the fish is once well outlined, I find it is better not to section the whole egg, but with fine scissors to cut off the embryo, and if possible shake it free from the egg membrane. With a little care the whole body may be obtained unbroken and entirely free from yolk, and yet with the periblast layer attached.

For surface preparations of the blastoderm during the stages of segmentation and formation of the periblast, the Perenyi embryos mounted in balsam answered fairly well. But much better preparations were obtained by killing the eggs in acetic acid, or in osmic and acetic, and mounting the embryos directly in glycerine.

I take this opportunity of thanking the Boston Society of Natural History and its librarian, Dr. J. Walter Fewkes, for the extremely obliging manner in which they have sent to Wood's Holl whatever books and journals I have asked for.

There are already several monographs in which the growth of our knowledge of Teleost development has been traced with great care, and I have therefore not considered it necessary to give extensive historical reviews. Hoffman's long paper (17) especially contains a full account of past work, and Henneguy's "Embryogenie de la Truite" (1888) brings the record nearly up to the present date.

I. SEGMENTATION.

The egg of the Sea Bass is a small pelagic egg about 1 millimeter in diameter. The egg membrane is thin and horny, but even after months in alcohol does not grow very hard. The yolk forms a single translucent sphere which, after coagulation of the albumen, shows in sections a finely reticulated structure. Imbedded in the yolk, but near the surface, is a single large oil globule, which is always uppermost in the floating egg. In the ripe unfertilized egg the yolk is covered by a thin layer of protoplasm, of about the same thickness at all points. Shortly after fertilization this diffused protoplasmic layer begins to concentrate towards a point just opposite the oil globule. The "streaming" of the protoplasm, which characterizes the concentration, has been well described and figured by Ryder for the Cod (34). A couple of hours after fertilization there is found at the lower pole of the floating egg a disk of protoplasm, lenticular in section. At its edge the disk thins away into an excessively thin

layer of protoplasm which is continued round the yolk. The yolk itself contains no protoplasm except in the immediate neighborhood of the oil drop. About a third of the surface of the latter is covered by a cap of coarsely reticulated protoplasm, lacking a nucleus. Fig. 1 shows a section through the oil globule, *o. g.*, and its protoplasmic cap, *o. g. p.*, which is entirely free from the superficial (almost imperceptible) layer of protoplasm. This cap of coarse protoplasm is easily seen in surface views, and I have observed it in Mackerel eggs as well as in those of the Bass.

The patch of protoplasm at the lower pole, or the blastodisc, is at first circular. Just before or during the first act of cleavage there arises an inequality of the axes, so that by the time the first two blastomeres are marked off, the germ is bilateral, or at least biradial (Fig. 2). In the Bass and Mackerel the first two blastomeres are of equal size. This is normally so with the Cod as well, but on one occasion I observed that in all of the eggs got from a single codfish, the first two blastomeres were unequal in size. The inequality was very marked, but the eggs were healthy and the average percentage of fish was hatched out.

The first plane of cleavage is claimed by Agassiz and Whitman (1) to represent the anteroposterior axis of the adult. I found that while I could follow with ease the succession of furrows until thirty-two cells were formed, and in some blastoderms could follow the process a step further until sixty-four cells were established, after that I could no longer trace the fate of the early cleavage planes.

The segmentation of the Bass is of the ordinary bilateral type characteristic of Teleostei. The first two planes of cleavage (Fig. 2) are meridional, and at right angles to each other. They cut very deeply into the blastodisc, but do not extend quite through to the yolk. The section (Pl. LXXXIX, Fig. 13) really belongs to a stage of four blastomeres, but does not differ in appearance from one through the two blastomere stage. As is seen in this section, the two segments and later the four are connected by a thin layer of protoplasm (*c. p.*, central periblast), in the center of the blastodisc. At the periphery the segments are continued into the superficial protoplasm clothing the yolk, which protoplasm is especially thickened round the immediate edge of the segments. The ridge thus formed (early periblastic ridge, *e. p. r.*, Figs. 2, 8, etc.) persists from the time when cleavage begins until the periblastic nuclei are established as such (Fig. 22). During all this time it constantly varies in distinctness, now being very obvious and again scarcely perceptible. It has long been known that the blastodisc increases in size during segmentation, and the fluctuation in the height of the ridge is undoubtedly due to some periodicity in the force, which effects the incorporation of the outlying protoplasm into the blastodisc. Agassiz and Whitman (*l. c.*, p. 49) discuss this point and conclude that the force is in some way associated with nuclear division. The ridge, which I have called the "early periblastic ridge," to distinguish it from the peripheral periblast wall which is formed in a much later stage by the fusion of certain of the blastoderm cells, is shown in section in Figs. 15, 16, Pl. LXXXIX, Fig. 17, Pl. XC. In Fig. 13, Pl. LXXXIX, and Fig. 14, Pl. LXXXIX, the ridge is at its lowest ebb, so to speak, and the blastomeres fade away gradually into the surrounding protoplasm.

The third cleavage plane is shown in Fig. 3. It is in most eggs nearly, and often quite, parallel to the first plane. In this stage the segmentation cavity, *s. c.*, which is perfectly distinct after another cell division, becomes recognizable. Figs. 14 and 15, Pl. LXXXIX, are two sections through the planes *a* and *b*, respectively, of Fig. 3. In the

outer section (Fig. 14) all the cells are fused at their bases. In the inner section (Fig. 15) one of the cells (1) is free from the periblast layer below *c. p.* Just a little nearer the middle line of the blastoderm the other cell (2) also becomes free of the periblast. The segmentation cavity, of which *s. c.* in Fig. 15 represents a part, is very obvious in surface views of this stage, when the lower surface of the blastoderm is brought into focus. In Fig. 3 the upper surfaces of the eight cells are closely joined, edge to edge, but at the lower level the central ends of the cells inclose a well-marked space, *s. c.*, the floor of which is formed by the periblastic layer. Occasionally there occurs at this stage a displacement of cells, or one of the blastomeres is retarded in its cleavage, so that there results an irregular blastoderm as shown in Fig. 4. In the Bass such irregularities are rare. I was surprised to find how comparatively common they were in mackerel eggs.

In Fig. 6 the fourth furrow is seen beginning. The sixteen cells formed by this furrow, after they have suffered another nuclear division, are shown in Fig. 8, Pl. LXXXVIII. A section through *a–b* of Fig. 8 is given in Fig. 16, Pl. LXXXIX. The segmentation cavity (*s. c.*) is now plainly established, the four central cells of Fig. 8 being entirely free from the periblast, and the cavity even extending well under the peripheral cells.

The fifth act of cleavage is indicated by the nuclear figures in Fig. 8. The cleavage plane of the corner cells (*x*) is meridional, but in the remaining peripheral cells the plane is equatorial. The four central cells on the other hand suffer a horizontal cleavage (plane parallel to the surface of the blastoderm), which can only be observed in sections, Fig. 16, Pl. LXXXIX. By no means do all of the eggs pass through this act of cleavage in such a strictly bilateral fashion. In a watch crystal of eggs, at least one-half of them will be found to deviate from the type. The most common variation concerns the terminal and lateral pairs of cells (m, n; m', n'; l, r; l', r', in Fig. 8). In one or two of these cells the cleavage is often meridional instead of equatorial. Thus in Fig. 9, l and r' (both belonging to the lateral pairs) exhibit the variation, and in Fig. 10, m', belonging to a terminal pair, likewise divides meridionally. The four central cells invariably divide in a horizontal plane, and it is rare to find a corner cell (x) which varies. Occasionally, however, one is found dividing equatorially.

Fig. 17, Pl. XC, lies in the plane *c–d* of Fig. 8, and is from a blastoderm, in which this stage of cleavage is near its close. The thirty-two cells are here nearly separate. When they are completely established and the resting stage comes on, there is invariably some rearrangement which partially destroys the bilaterality of the germ. Even, however, where the rearrangement is coupled with a previous variation, such as Figs. 9 and 10 exhibit, the origin of the thirty-two cells can often be made out. Thus Fig. 11 shows a resting blastoderm of this stage, in which I have given each cell the letter of its immediate parent, as used in Figs. 8, 9, and 10. In Fig. 12, Pl. LXXXIX, however, in which the thirty-two cells have suffered nuclear division, the displacement of cells has been so great that it is impossible to trace the original bilaterality, just as it was impossible to follow with certainty the movements of the cells in the living egg under the microscope. During the last minutes of the thirty-two cell stage, it may be said that all degrees in the loss of bilaterality are found, and consequently it is only in certain embryos that the cleavage from thirty-two into sixty-four can be accurately followed.

There are certain general features in this sixth act (32 into 64) of cleavage, which were found in all the eggs I studied, and from which, coupled with the behavior of

some unusually symmetrical embryos, it is possible approximately to deduce an ideal type, which, it may safely be said, is never exactly followed in actual segmentation. In Fig. 12 it is seen that the cells of the peripheral ring undergo either meridional or equatorial division, but it is impossible to decide from the relative frequency which should be regarded as the type.

Figs. 18 and 19 are two sections through unusually symmetrical germs, in which the thirty-two cells had nearly retained the positions indicated by the amphiasters of Fig. 8. They may be referred to the ideally symmetrical thirty-two cell stage, as represented by Fig. 1. Fig. 18 would lie in the plane *a–b*, and Fig. 19 in the plane *d–f*. In Fig. 18 the lower tier (four in all) of central cells, c_2, are in the first stages of nuclear division. The cleavage planes of these four cells, then, run in the direction *x*, Fig. 1. Fig. 19 shows that the four upper central cells (c_1) suffer cleavage in planes parallel to *y*. These planes, *x* and *y*, may be taken as typical for the central cells, though there is undoubtedly much variation, but never in the direction of horizontal cleavage. The horizontal cleavage is exclusively found in the cells which lie between the central cells and the peripheral ring, viz, in m_2, n_2, etc. In Fig. 19 two of these cells, m_2 and m_2', show this cleavage.

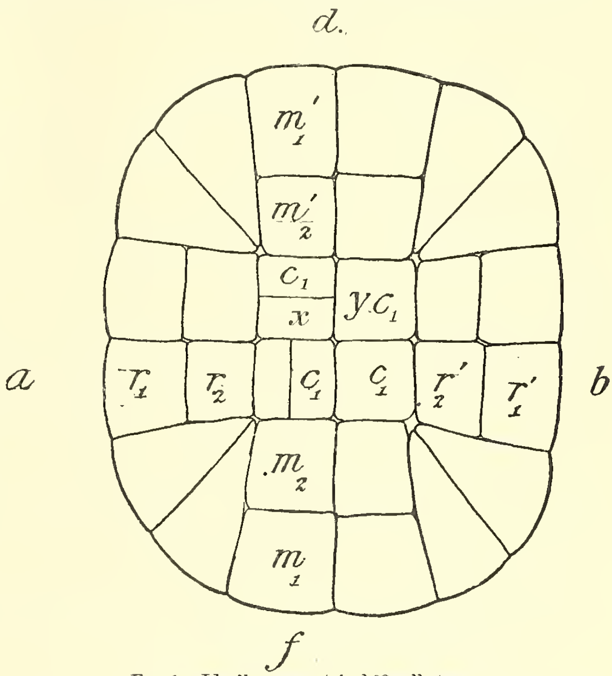


FIG. 1.—Ideally symmetrical 32-cell stage.

The typical cleavage from thirty-two cells into sixty-four may then be described as follows: The peripheral cells suffer meridional (equatorial) division, the intermediate cells, m_2, n_2, etc., horizontal division, the four upper central cells and the four lower central cells divide in planes parallel to *y* and *x*, respectively, these planes, being, in all probability, metamorphosed meridional planes. The further course of segmentation I found it impossible to follow. Fig. 20, Pl. XC, is through a blastoderm about an hour older than Fig. 19. The peripheral cells continue to divide meridionally or equatorially, the plane obviously being decided in many cases by the greater length of one of the cell axes.

During the segmentation the periods of rest are, as usual, long compared with those of activity. I give the following time record of the early divisions:

11:40 to 11:58 (18 minutes) period of rest; 4 blastomere stage.

11:58 to 12 (2 minutes) period of activity; 4 into 8 blastomeres.

12 to 12:27 (27 minutes) period of rest; 8 blastomere stage.

12:27 to 12:30 (3 minutes) period of activity; 8 into 16 blastomeres.

Bilaterality of the blastoderm.—Occasionally a blastoderm is met with which suggests that the bilaterality in at least the early stages is very deeply seated indeed.

Such a one is given in Fig. 7. Here both cells of one lateral pair (*l* and *r*) have deviated from the type and are undergoing meridional division, and both cells of the opposite pair are doing likewise. This state of affairs is, however, not the rule, and serves rather as a suggestion than an argument. But what is the rule, is the exact agreement between the corresponding cells of opposite halves as to the time when cellular fission begins. The furrows appear at precisely the same instant in *r* and *r'* and *l* and *l'*, and the same was true of the terminal cells *m*, *m'* and *n*, *n'*. In the ordinary blastoderm, as shown in Fig. 6, all the furrows start at exactly the same time. Such correspondence between the opposite halves plainly suggests that the bilaterality is not simply a morphological one, but that the symmetrical arrangement of cells is the mere outward expression of a physiological bilaterality which already exerts a control over the life of the organism.

Watase has shown in his careful study of the Squid segmentation (41 and 42) that the bilaterality is there even more prominent than it is in the Teleost. If, for instance, a cell on one side exhibits such a variation as multinuclear fission, the corresponding cell on the opposite side will do the same. The relation between the right and left halves of the blastoderm in regard to the time when activity begins is, however, of a very different character in the two animals. In the Squid there is an alternation in the activity of the two sides; one side undergoes nuclear division while in the cells of the opposite side the nuclei remain in the resting stage. In the Teleost, on the contrary, there is coincidence between the two halves of the blastoderm as regards activity and rest. This is certainly true of the cellular division, and without having studied the nuclear fission in anything like the detail which characterizes Watase's work on the Squid, I feel sure that the same coincidence is present in this form of activity as well. I never found resting nuclei on one side and amphiasters on the other, but the resting nuclei, sharply outlined and conspicuous, always made their appearance on the two sides at the same time, and as soon as amphiasters could be recognized on one side they could be found on the other.

Amphibian and Teleostean segmentation.—The teleostean segmentation has undoubtedly been derived from a total segmentation essentially like that of Amphibia, and, convinced of this, Rauber (36), Agassiz and Whitman (1), and Ziegler (47) have endeavored to homologize the early furrows in the two groups. In regard to the first two furrows there can be no difference of opinion. The homology of the third teleostean furrow is, however, by no means so clear. Ziegler, without entering into a detailed discussion of the matter, regards the first three furrows in the two groups as homologous. Agassiz and Whitman, after a critical examination of Rauber's views, also pronounce in favor of this homology, deciding that the third teleostean furrow represents the equatorial furrow of Amphibia. I do not find, however, their reasons sufficient for discarding the homology offered by Rauber, supported as it is by variations (atavistic) in the teleostean germ towards the Amphibian type, and by variations in the Amphibian segmentation which so exactly imitate the teleostean type.

In his extremely suggestive paper Rauber (36) shows that the generally accepted account of the frog's segmentation is erroneous. The furrows have not the ideally symmetrical arrangement given in the common figures. It is very rare even for the second meridional furrow to cross the first at the poles of the egg, and Rauber never observed an egg in which the first three meridional furrows so cross. Commonly the two furrows, which together compose the so-called second meridional furrow, meet the

first furrow at points on opposite sides and a short distance from the poles. For the sake of convenience the cut Fig. 2 may be used as an illustration, though it does not represent the most common type of the frog's segmentation. Supposing p to be the upper pole of the egg, the first furrow a–a and the second furrow b–b cross at points some distance from the pole. Whatever be the precise cause which makes the furrows in the frog thus avoid the pole, the avoidance is a fact, and to it Rauber has given the name of *Polflucht*. The third meridional cycle of furrows (the true third or equatorial is represented by the bounding line c in the figure) exhibits the same phenomenon. The individual furrows run from the equatorial furrow not to the pole, but into the several older furrows; for instance, the line x may represent the course of the furrow in this cycle. All degrees of *Polflucht* may be found, and when the degree is great enough, and is coupled with the occurrence of certain other features, the type of segmentation shown in Fig. 2 is produced. This type while unusual is not very rare. Its similarity to, almost identity with, the 8-celled stage in the Teleost, can not be overlooked, and I think Rauber is justified in regarding the third teleostean furrow as homologous with the furrows 1, 2, 3, 4. This homology is further strengthened by the occurrence of a variation in the Teleost, which may be interpreted as a reversion, and as indicating that the third furrow in the fish egg was originally a true meridional furrow, or at least one with very little Polflucht. Such a variation is shown in Fig. 5, Pl. LXXXVIII (Mackerel). It is certainly very rare in the Bass and Mackerel, and the blastoderm figured was apparently pathological. Agassiz and Whitman record the occurrence of the same variation in *Ctenolabrus* (I, Pl. CVII, Fig. 35).

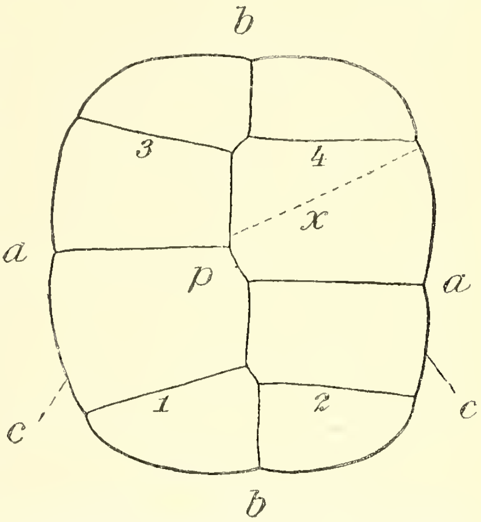


FIG. 2 (from Rauber, 36).—Variation in the frog's segmentation, imitating teleostean segmentation—p., animal pole; a. to a., first furrow; b. to b., second furrow; c. to c., equatorial furrow; 1, 2, 3, 4, fourth furrow.

According to Rauber the first equatorial furrow of the frog has been lost in the Teleost. Agassiz and Whitman would seem to believe that the *a priori* improbability of such a loss taking place is so great that, in spite of the variations just described, it is preferable to regard the first three furrows as homologous in the two groups. I do not see the inherent improbability of the loss. On the contrary, the disappearance of segmentation in the ventral half of the egg, coupled with the early contraction of the protoplasm (belonging to this half) towards the upper pole, make it easy, I think, to understand how the loss was brought about.

II. FORMATION OF THE PERIBLAST.

The existence of yolk nuclei in the Teleost egg (parablast nuclei, His; periblast nuclei, Agassiz and Whitman) was discovered as long ago as 1854 (Lereboullet, 31), but their origin was first made out by Agassiz and Whitman in 1884 (1). These authors proved beyond a doubt that in *Ctenolabrus* the nuclei are derived from the marginal cells of the blastodisc, which, from the earliest stages of segmentation are

connected with the yolk (or periblastic) protoplasm. The marginal cells so connected eventually lose their cell outlines, and are drawn into the surrounding protoplasm. In *Ctenolabrus* there are two concentric rings of cells thus made use of. Before the appearance of their paper it had been held by Kupffer and others that the nuclei originate in the yolk independently of the blastodisc nuclei. Hoffmann (17), on the other hand, claimed that the first segmentation nucleus underwent a horizontal cleavage, the upper daughter nucleus giving rise to the nuclei of the blastodisc, while, from the lower daughter nucleus were derived the nuclei of the periblast. Agassiz and Whitman have sufficiently criticised Hoffmann's account and figures, and while there is good reason to believe that the periblast nuclei do not originate in all Teleosts from the peripheral cells of the blastodisc (von Kowalewski, 27) their criticism seems to me a very just one.

I have found that the nuclei develop in *Serranus* in a manner almost identical with that in *Ctenolabrus* There are minor differences concerning the number of rings of marginal cells drawn into the periblast, etc., but my account is essentially a confirmation of that of Agassiz and Whitman.

At the end of segmentation the marginal cells of the blastodisc are flattened and do not take the stain as readily as the other cells. In a surface view (Fig. 21, Pl. XC), they appear as a wreath of pale cells round the periphery of the blastoderm. This wreath of cells, often observed (Kupffer, 24; Van Beneden, 40; Ryder, 35; Cunningham, 8; Henneguy, 18), has been and is still the subject of great misconstruction. Kupffer and others believed that these cells were formed round nuclei, which had originated in the yolk, and that they then passed out of the yolk and were added to the blastodisc. It might be thought that the very lucid and exact account of Agassiz and Whitman would have cleared this part of teleostean embryology from any shade of uncertainty. But in his last paper (18) so old a student of the Teleosts as Henneguy concludes that the cells of the "wreath" are passing out of the periblast "pour s'ajouter au germe" (p. 461).

In Fig. 21 the marginal cells, though very different in appearance from the rest of the blastoderm, still retain their cell outlines. They are even marked off from the surrounding periblastic protoplasm, which continues to form round the edge of the blastoderm the "early periblastic ridge." A few minutes later there is no longer any line of separation to be seen between these cells and the outlying protoplasm, though they are still marked off from one another (Fig. 22, Pl. XC). Sections through this stage are the most important for the study of the formation of the periblast. Fig. 25, Pl. XCI, is such a section, in which the right half presents a slightly older condition than the left. On each side the marginal cells pass without the interruption of the ridge into the cortical layer of protoplasm (*cor. p.*). On the left, however, the marginal cell still preserves its earlier shape; the segmentation cavity cuts its way into it (compare earlier sections, Figs. 20, 19, 18, etc.). But on the right the cell is flatter, and the whole body passes uninterruptedly into the central periblast layer (*c. p.*). The section shows plainly enough that the marginal cells are being drawn into the periblastic protoplasm.

An hour later (Fig. 23, Pl. XC) the marginal cells have fused with one another, and the lost cell outlines are now only indicated by the accumulations of protoplasm round the nuclei. In sections through this stage it is seen how completely the peripheral cells have lost their identity in the process of fusion with each other and the periblast. In Fig. 26 the marginal cells of Fig. 25 have been metamorphosed into the

periblastic wall (*p. w.*), which as yet contains but a single circle of nuclei. There takes place at about this time a flow of protoplasm from the wall towards the center of the blastoderm, whereby the central periblast layer becomes thicker than in earlier stages.

During the next hour there is an active multiplication of nuclei in the periblast wall. The indirect method of division is followed, and the karyokinetic figures are very conspicuous, especially in surface views (Fig. 24). Succeeding the single ring of nuclei shown in Fig. 23 there is a stage with two concentric rings, though the two rings can not be distinguished at all parts of the periphery. After this the arrangement of the nuclei is no longer a regular one, as is proved both by surface views and series of sections. In Fig. 28 the periblastic wall contains four nuclei, but other parts of the wall show only two or three (Fig. 27). All the periblastic nuclei of a blastoderm do not suffer division at the same time, but it sometimes happens that the nuclei of a particular region all divide at once, as shown in Fig. 24, though on the opposite side of the blastoderm from which this view was taken the nuclei were in general at rest.

The multiplication of the nuclei in the wall is followed by a gradual migration towards the center of the blastodisc. In Figs. 27 and 28 the inner nuclei have begun to creep in this direction, and the migration continues until nuclei are scattered all through the periblastic layer. This migration from the edge of the blastodisc is illustrated by the series of sections, Figs. 29, 30, and 31, which are from blastoderms of 9½ hours, 14 hours, and 16 hours, respectively. The periblastic wall, which is so prominent at the beginning of migration (Fig. 29), grows less conspicuous towards its end (Fig. 31). This is due in part to a gradual flow of the periblastic protoplasm towards the center of the blastodisc, and in part to the increasing size of the blastodisc, the edge of which, as it grows round the yolk, carries with it the periblastic wall.

The histological change which occurs in the periblastic nuclei, and which appears to be universal in Teleosts and Selachians, comes on in the early stages of migration. After the stage shown in Figs. 28 and 29, of about the same age, there is no longer any indirect division of nuclei; and the nuclei themselves, which have hitherto not differed in appearance from those of the blastodermic cells, now become greatly vacuolated and also flattened. They gradually increase in size and their contour becomes very irregular, owing to the development of protuberances. The peculiar character which they retain throughout embryonic life is fully acquired before invagination begins (Fig. 32, Pl. XCI, and Fig. 40, Pl. XCIII).

The physiological use of the periblast nuclei and protoplasm is not known. The suggestion has, however, been advanced (Hoffmann, 17; Ziegler, 47) that the nuclei have the function of working over the yolk into some shape which is easily assimilated by the blastodisc cells. Their uniform histological character in the Teleosts and Selachians naturally leads one to believe they have some special physiological function, the more so because, though ancestrally a part of the entoderm, in the ontogeny (of the Teleosts, at least) they take no share in forming the embryo. Like Hoffmann (17), Wenckebach (43), Ziegler (47), Henneguy (18), and in opposition to Kupffer (26), and Gensch (13), I find that the nuclei do not give rise to blood cells, nor do they contribute to the formation of the alimentary canal. The ultimate fate of the nuclei is associated with the final disappearance of the yolk sac through the agency of the liver.

III. INVAGINATION.

During the formation of the periblast the superficial layer of the blastodisc cells becomes differentiated from the rest to form what German authors usually call the "Deckschicht," English writers the "epidermic stratum." The progressive flattening by which these cells are converted into a well-marked layer may be traced through Figs. 25, 26, 27, Pl. XCI, into Fig. 40, Pl. XCIII. The latter section is through the stage when invagination begins, and the epidermic stratum (*ep. s.*) is fully differentiated. The flattening continues through later stages until the layer is reduced to the condition of a very thin membrane, which stains deeply.

During the same period the blastodisc undergoes a change of shape, which is the preparatory step towards invagination and the differentiation of the embryo. During the last stages of segmentation, when the periblast wall is being formed, the under surface of the blastodisc is either plain or slightly convex (Figs. 26 and 29, Pl. XCI). Four hours later (Fig. 30, Pl. XCI) the under surface has become decidedly concave. As the hollowing out continues the concavity takes an eccentric position (Fig. 31, Pl. XCI), and thus before any invagination occurs one part of the peripheral region of the blastoderm is thicker than the rest. In a surface view of this stage the thin eccentric area appears as an ill defined clear circular space, surrounded by the more opaque periphery, which at one pole (*p. p.*, Fig. 32, Pl. XCI), the tail end of the future embryo, is considerably thicker than elsewhere. At this pole, in Fig. 32, the invagination has already begun, and hence the periphery is here separated by a sharp line from the central region. But before the invagination begins this part of the edge is noticeably thicker than the rest, though nowhere is the peripheral region sharply marked off from the central. As to the means by which the center is thinned out, and the periphery, especially the embryonic pole, left thicker, I can only say that in general I agree with Götte (14). In the absence of any absorption of cells or extensive migration, the cause would seem to lie in the direction of cell growth, which in the main determines the position of nuclear cleavage planes, and hence the direction in which new cells are pushed.

The change of shape which the blastoderm suffers during this period gives rise to what is commonly called the subgerminal cavity, *i. e.*, the cavity which may be supposed to exist between the blastoderm and the periblast layer in Figs. 30, 31, Pl. XCI, Figs. 40, 41, Pl. XCIII. This cavity was in almost all the embryos I examined a virtual one, except at certain points where the bounding layers separate slightly, as in Figs. 40, 41, etc. (*s. g. c.*) Occasionally, however, an embryo was found in which a comparatively spacious cavity separated blastoderm and periblast, as in Fig. 47, Pl. XCIV. It will be understood that the subgerminal cavity is merely a late phase of the segmentation cavity of the earlier stages, *s. c.*, Fig. 25, etc.

The next preliminary step in the process of invagination is illustrated by Fig. 32, Pl. XCI, and by an antero-posterior section through the posterior pole of a similar blastoderm, Fig. 40, Pl. XCIII. In the surface view the peripheral region at the embryonic pole is seen to be bounded internally by a sharp line, and in the section Fig. 40, the explanation of this line is found in the well-marked randwulst, the inner limit of which is indicated by the cells *m*, *m′*. The mode of formation of the randwulst may be inferred from the shape and arrangement of the cells and the position of the daughter nuclei. Cell-growth, following the arrow *a* (Fig. 40) first established in the blastoderm a

thinner center and a thicker periphery; then, curving round in the direction of arrows *b* and *c*, it gave rise to a marginal wulst (see cut, Fig. 3).

Still confining our attention to the embryonic pole of the blastoderm, we see, Fig. 41, Pl. XCIII (antero-posterior section through a stage slightly older than Fig. 40) that a tongue of cells grows out from the randwulst towards the center. The tongue (*pr. h.*), several cells deep, can be recognized with ease before there is any ingrowth at all round the rest of the blastoderm edge. (Compare opposite halves of Fig. 41.)

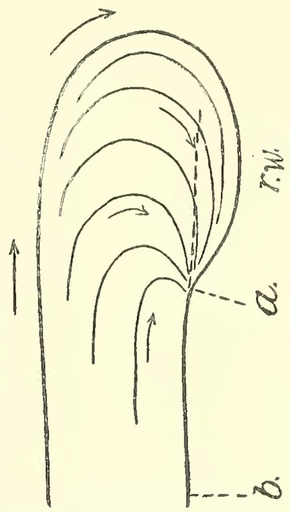


FIG. 3. Diagrammatic section to illustrate formation of randwulst—*r. w.*, randwulst; *a.*, apical line.

Round the rest of the edge the ingrowth is likewise, at least in most places, preceded by the formation of a randwulst, which, however, is inconspicuous. In Fig. 46, Pl. XCIV, a longitudinal section through the anterior pole of a blastoderm similar to Fig. 33, Pl. XCII, the periphery of the section is seen to be slightly thicker than the inner part. From the thickened periphery the ingrowth of cells (*v. mes.*) has already started, though only the apical cell is as yet clearly separated from the upper layer. In the transverse section, Fig. 47, Pl. XCIV (through *a–b* of Fig. 33), a randwulst can not be said to exist, the edge of the blastoderm from which the ingrowth (*v. mes.*) starts being actually thinner than the more central portion.

The early condition of the ingrowing layer at the cardinal points of the blastoderm, posterior pole, anterior pole, and lateral poles, is shown in the three sections, Fig. 41, Pl. XCIII (right half), Fig. 46, Pl. XCIV, and Fig. 47, Pl. XCIV, and a surface view of the blastoderm at this stage is given in Fig. 33. The ingrowing under layer is known as the germ ring. Before going further I must dissent from a point in the description which Agassiz and Whitman (*l. c.*) give of the formation of the ring. In their Fig. 6, corresponding with my Fig. 47, the cells of the ring are represented as forming a differentiated unicellular layer extending quite out to the epidermic stratum. In their paper, which is a preliminary one, the transverse section is the only one given, and they do not describe the condition at the embryonic pole. I have not found that the under layer cells are differentiated from the rest of the blastoderm at the extreme edge. The peripheral part of the blastoderm, both where there is a large randwulst, Figs. 41 and 46, and none at all, Fig. 47, is an undifferentiated area, and the germ ring consequently starts at some little distance from the extreme edge of the blastoderm.

I have not as yet mentioned the behavior of the epidermic stratum during the period of invagination. Like most authors I have found that this stratum does not share in the invagination. It is at no point continuous with the ingrowing layer, as all the figures show. The peripheral epidermic cells at the embryonic pole, however, act in a way which at least suggests the persistence of a tendency in them to take part in the invagination, though it is more probable that their behavior is due to some much less significant cause. The peripheral cells (*m. ep. c.* Figs. 40 and 41, Pl. XCIII, Fig. 45, Pl. XCIV), in this region during the early stages of invagination, are larger than elsewhere, and they project into the narrow ring-like space left between the periblast and the incurving surface of the randwulst. Fig. 41 shows the ordinary amount of this projection, but blastoderms are met with in which the epidermic layer follows the sur-

face of the randwulst in as marked a manner as is shown in Fig. 45. Round the rest of the blastoderm edge the marginal epidermic cells are often larger than the others, but there is nothing striking in their behavior, and after the first stages of invagination the peculiar character of the cells at the embryonic pole is lost (Figs. 43 and 44, Pl. XCIII).

The germ ring, the origin of which has now been described, continues its centripetal growth for a short while around the entire edge of the blastoderm, but especially in the region of the embryonic pole. In a surface view, Fig. 34, Pl. V, an hour later than Fig. 33, the inner outline of the germ ring (*g. r.*) is seen to have encroached upon the central clear space (the thin roof of the subgerminal cavity), and in a section, Fig. 43, Pl. XCIII, the short, thick tongue of cells shown in Fig. 41 is seen to have grown out into a thin sheet of uniform thickness, *pr. h.* (two layers of cells). Still an hour later this part of the germ ring has approached considerably nearer the center, Fig. 44, Pl. XCIII, preserving its characters of a simple two-layered sheet, which indeed it does not lose until the formation of the notochord begins. The growth of the germ ring round the rest of the blastoderm edge may be gathered from a comparison of Figs. 46 and 48, Pl. XCIV, both longitudinal sections through the anterior pole of the blastoderm (Figs. 48 and 44 are parts of same section). The ingrowth (*v. mes.*) is seen to be very slight compared with that at the embryonic pole, and moreover the cells of the under layer are not arranged in two strata.

The positive means by which the ingrowth is effected is undoubtedly cell division. (See the nuclear spindles in Figs. 46 and 48.) But as Agassiz and Whitman (*l. c.*) have pointed out, the width of the ring is probably also increased in a passive manner by the spreading of the blastoderm round the yolk.

There is one very striking and theoretically important feature which comes out in the comparison of the early and later stages of the germ ring. If Fig. 41, Pl. XCIII, be compared with Fig. 44, Pl. XCIII, it will be seen that the germ ring has not only grown in a centripetal direction, but that it has also been splitting off in a centrifugal direction from the randwulst. This point is brought out even better in a comparison between Figs. 46 and 48, Pl. XCIV. In other words, accompanying the ingrowth or invagination, there has been a backward (centrifugal) delamination, slight, indeed, but still a fact. Götte, the discoverer of invagination in the Teleosts, is the only writer who speaks of the centrifugal delamination in the randwulst, though, as I shall point out later, Götte's randwulst is really a stage of the germ ring in which the actual ingrowth has already begun.

The significance of the centrifugal delamination lies in the suggestion it gives of the way in which invagination may be converted into delamination. It is, to be sure, very doubtful whether there is any vertebrate in which the primitive hypoblast is really delaminated from the upper layer. But in the very similar case of the origin of the mesoblast from the primitive hypoblast, there is no doubt that in certain animals delamination has superseded the folding process (see section on mesoderm), and any occurrence which points to the way in which the one method may be converted into the other, seems worth recording.

In the cut, Fig. 3, the concentric lines of cell growth by which the randwulst is established, meet in what may be called the apical line *a*, which marks the inner edge of the randwulst. From this zone the ingrowth progresses centripetally, and a cen-

trifugal delamination also takes place in the direction of the dotted line. Now, by a slight alteration in the course of the lines of growth, the zone in which they all meet, or the apical line, may be made to move centrifugally or centripetally, and if, for instance, it take the position *b*, an extremely wide randwulst will be established. In this hypothetical randwulst, as in the real one, there would at first be no differentiation of layers, but by the quick and simple process of delamination the under cells of the wulst could be converted into a separate layer, as actually occurs in the real wulst. By moving the apical line far enough towards the center, the entire germ ring could be established by delamination, without there being any need of an actual ingrowth.

The germ ring as such reaches the height of its development about 20 hours after fertilization (Figs. 34 and 35, Pl. XCII, Fig. 44, Pl. XCIII, Fig. 48, Pl. XCIV, all of the same age). The thinning out of the central region to form the subgerminal cavity (*s. g. c.*), which was begun in earlier stages, has been continued. The thin region now, however, has very definitely circumscribed bounds. It is inclosed on all sides by the germ ring (Fig. 34) in the region of which, especially in the neighborhood of the embryonic pole, the upper layer of cells (which may now be called ectoderm) remains thick (Fig. 44). The thin region, or extra-embryonic part of the blastoderm, consists at this stage of three layers of cells—the epidermic stratum and two strata of nervous layer cells—which are still plump polygonal bodies. This region continues to grow thinner, but reaches its ultimate condition before the blastoderm has covered the yolk. It is then a thin membrane, made up of epidermic pavement cells and one or two layers of somewhat flattened cells.

Historical.—To Götte belongs the credit of the discovery that in the Teleost embryo there is a process of invagination leading to the formation of the primitive hypoblast, which in its turn splits up into entoderm and mesoderm. The account given in his first communication (1869, 15) was scarcely an exact description of the facts, but his second paper (14) contains a more accurate and detailed account than any I have found in subsequent papers.

In his first communication Götte described the edge of the blastodisc as suffering an actual involution to form the under layer, and this account was repeated by Haeckel in the description he gives of Teleost development in the "Gastræa Theorie" (19). In 1873 Oellacher published his well-known paper on the Trout (33), in which he claimed there was no invagination at all, but that the eccentric thinning out which led to the formation of the subgerminal cavity also left one portion of the peripheral region much thicker than the rest (embryonic anlage). This thicker portion of the periphery then split into the ectoderm, mesoderm, and entoderm of the embryo (delamination theory). Shortly after the appearance of Oellacher's paper Götte published his second account, with which my own description agrees in all essential particulars. The one point of difference concerns the randwulst. What Götte has described and figured under this name is really a stage of the germ ring, in which the free ingrowth has already begun. It corresponds with the ring shown in my Fig. 42, Pl. XCIII, or more highly magnified in Fig. 46, Pl. XCIV (anterior pole), and Fig. 41, Pl. XCIII, right half (posterior pole). As will be seen from the following brief abstract of Götte's description, the only improvement I have been able to make upon it lies in having defined the randwulst with somewhat greater precision. According to Götte the thinning out by which the subgerminal cavity is established is the result of the direction of cell growth, which

(see cut Fig. 4), starting from *a*, proceeds in the direction of the arrows. After the subgerminal cavity is formed the cell growth continues round the periphery in the same general direction (arrow) and a randwulst is established. In the region of the

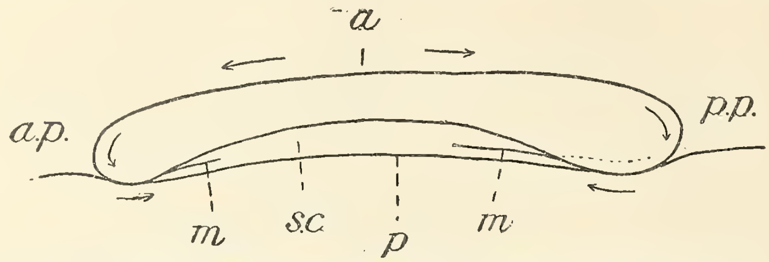


Fig. 4.—Diagrammatic section through a blastoderm to illustrate Götte's account of the development of the randwulst and germ ring; *p. p.*, post. pole; *a. p.*, ant. pole.; *m.* to *m.*, germ ring; *s. c.*, segmentation cavity; *p.*, periblast.

randwulst there is no differentiation of layers, but the cell growth continuing centripetally produces the layer *m–m*, sharply marked off from the layer above. In a somewhat later stage the differentiation of the under layer *m* extends back into the randwulst itself, in the direction of the dotted line.

Subsequent observers have either followed Oellacher's account (Hoffmann, 17) or have been content to describe the main fact of an ingrowth from the edge of the blastodisc, without entering into a discussion of the randwulst (Henneguy, 18; Agassiz and Whitman, 1; Cunningham, 8).

The consideration of the germ ring as a part of the gastrula will be found in a later section.

IV. NOTOCHORD, MESODERM, ENTODERM.

Formation of embryonic shield.—After the germ ring is completed the growth of the blastoderm round the yolk is continued with much greater rapidity than in earlier stages. In a stage 5 hours later than Fig. 35, Pl. XCII, two-thirds of the yolk is inclosed, Fig. 36, Pl. XCII. In the spreading of the blastoderm, the posterior pole or tail end of the embryo remains as a comparatively fixed point, while the anterior pole, *a. p.*, Fig. 35, travels rapidly in the direction of the arrow. The constant position of the oil globule with respect to the early blastodisc enables one to judge of this movement with certainty.

During the growth of the blastoderm the embryonic area in the region of the posterior pole becomes sharply marked off from the rest of the blastoderm. The area thus marked off is commonly known as the embryonic shield. The manner in which it develops is brought out in a comparison of Fig. 34, Pl. XCII (20 hours), with Fig. 37, Pl. XCII (25 hours). As the anterior pole of the blastoderm travels round the yolk, and the extra-embryonic region is thus increased, the head end (*h. e.*, Fig. 34) of the future embryo travels in the same direction, and in this way a roughly triangular area (embryonic shield) is established which projects into the surrounding extra-embryonic region. The outline of the embyronic shield in Fig. 37 is indicated by the letters *e. e. s.* In this figure the embryo itself is distinctly marked out as a median longitudinal thickening. A stage intermediate between Figs. 34 and 37 would show a clearly differentiated shield, though less extensive than that of Fig. 37, without the median thickening.

During the growth of the blastoderm the part of the germ ring not included in the embryonic shield, extra-embryonic part of ring, grows thin and its cells become flattened, as over the rest of the non-embryonic area. The change which takes place in this part of the ring between 20 and 25 hours is gathered from a comparison of Fig. 48 (F objective) with the older stage, Fig. 51 (D objective).

General structure of embryonic shield.—The ectoderm over the whole region forms a thickened plate, passing at the edge of the shield into the thin ectoderm of the non-embryonic area (Fig. 53, Pl. XCIV, transverse section through shield). The ectoderm plate is at first not thickened in the median line; on the contrary, just above the developing notochord it is somewhat thinner than elsewhere (Fig. 50, Pl. XCIV). The ectoderm cells are polygonal, except the epidermic stratum, and the layer is everywhere clearly marked off, often actually separated from the under layer or primitive hypoblast *pr. h.*, Fig. 50).

The primitive hypoblast over the greater part of the shield consists, as in earlier stages (Fig. 44, Pl. XCIII), of two strata of flattened cells. The strata are quite distinct, except in the middle line (Fig. 50, Pl. XCIV), where the cells are closely interlocked. The fusion which thus early appears in the primitive hypoblast along the median line is the first step in the formation of the notochord. At the lateral edge of the shield, where the primitive hypoblast ends abruptly, the two layers are not distinct (Fig. 53, Pl. XCIV), nor are they recognizable in the immediate neighborhood of the posterior edge, where the primitive hypoblast bends round into the ectoderm (Fig. 49, Pl. XCIV, a transverse section through the extreme posterior edge of the shield). As will be seen in Fig. 37, Pl. XCII, this edge of the embryonic shield exhibits a ring-like thickening continuous with the extra-embryonic germ ring, and the section given in Fig. 49, Pl. XCIV, shows that the thickening is located in the under layer.

In the anterior region of the shield the primitive hypoblast is not divisible into two layers. Fig. 52, Pl. XCIV, gives a longitudinal section, a little to one side of the median line, through a shield in which the embryo had just begun to be marked out as a linear thickening. Anteriorly the primitive hypoblast ends in a mass of polygonal cells, *a. m.*, which long occupy this position, just in front of and ventral to the future fore-brain. From this mass as far back as the point x, in other words, throughout the extent of the future brain area, the cells of the under layer are polygonal, and only indistinctly show two layers. Most, if not all, of the primitive hypoblast in the brain region becomes converted into mesoblast exclusively (head mesoblast; no somites).

Differentiation of the embryo and formation of notochord, etc.—The opaque linear streak which marks the body of the embryo, and which is shown in a somewhat advanced condition in Fig. 37, Pl. XCII, is in its first stage due almost exclusively to a thickening of the ectoderm. This thickening, by which the neural chord is formed, begins in the future head region of the embryo, which is thus marked off before the rest of the body. But in an hour's time the posterior region (trunk) of the shield has also acquired its median thickening (Fig. 53, Pl. XCIV, and Fig. 54, Pl. XCV, transverse sections through the trunk). The start thus obtained by the brain keeps it, however, from the beginning thicker than the spinal chord (Fig. 36, Pl. XCII, and longitudinal sections, Fig. 52, Pl. XCIV, and Fig. 55, Pl. XCV). For the present the neural chord may be passed over with this brief description of its origin.

By the time the neural chord has begun to form in the trunk region, the formation of the notochord and secondary layers has also commenced, by which the median

thickening is further increased. The development of these organs begins in the posterior region and travels anteriorly. Thus in the same embryo several stages in their differentiation may be observed. Fig. 53, Pl. XCIV, and Fig. 54, Pl. XCV, are two sections through the trunk of an embryo somewhat younger than that shown in Fig. 37, Pl. XCII. In the anterior section, Fig. 53, the condition is much the same as in the earlier embryo, Fig. 50, Pl. XCIV, but with this difference, the under, *en.*, of the two layers, found on each side of the incipient chorda, *nc.*, has definitely separated from the chorda and from the upper layer, *mes.* It is thus made up of separate halves which project slightly under the chorda cells. This layer constitutes the definitive entoderm. The intimate connection between the chorda cells and the layer marked *mes* (which develops into the mesoblast) is soon broken. The connection has no significance, for it sometimes happens that the chorda cells separate simultaneously from both entoderm and mesoderm. In the posterior section (Fig. 54) the differentiation has gone a step farther. The chorda has separated from both layers and has assumed a compact shape, though the cells have practically their former arrangement. The entoderm is in the same condition as farther forwards, but the unicellular mesoblast layer of Fig. 53 has begun on each side to thicken up at its inner angle. The thickening is as yet very slight, and extends but a short distance away from the notochord.

Let us trace the development of the notochord and secondary layers through a slightly older stage than that of Figs. 53 and 54. Of this stage a surface view from above is given in Fig. 37, Pl. XCII, from the side in Fig. 36, Pl. XCII, a median longitudinal section in Fig. 55, Pl. XCV, and a series of transverse sections (numbered from behind forwards) in Figs. 56, 57, and 58, Pl. XCV. From the surface views and the longitudinal section the relative extent of the head (brain) and trunk regions may be gathered. In the posterior trunk region (Figs. 55 and 56) the notochord is easily recognizable. The entoderm is in its former condition, or nearly so, still consisting of two lateral unicellular sheets which project under the notochord. The projection under the notochord (Fig. 56) is more marked than in earlier stages. The mesoderm plates have thickened considerably (compare Figs. 54 and 56). It is only near the edge of the shield that they now consist of a single layer of cells. On passing gradually into the anterior trunk region the notochord will be found to grow appreciably thinner (Fig. 55), likewise the mesoblast plates. Going still farther forwards into what may be called the neck region (*n*, Figs. 55 and 57), the notochord and entoderm fuse, and the mesoblast plates thin away into scattered cells (*mes.*, Fig. 57). In the head region (Figs. 55 and 58), in connection with the vertical development of the brain, the primitive hypoblast has thinned away into a unicellular layer, which in later stages is in part transformed into scattered mesoblast elements, and in part persists as the extreme anterior portion of the entoderm lamella.

Formation of the primitive streak and closure of the blastopore.—Before the early history of the notochord and layers can be concluded, it will be necessary to describe the course of development at the posterior end of the embryo. The condition at this end, after the completion of the germ ring, is shown in Fig. 44, Pl. XCIII, a median longitudinal section through a stage such as Fig. 35, Pl. XCII. When the blastoderm has grown round the yolk, as far as is shown in Fig. 36, Pl. XCII, the condition at this pole becomes a slightly different one. There is now at the posterior end of the embryo (Fig. 55, Pl. XCV, median longitudinal section) an undifferentiated mass of cells of considerable extent (*c. m.*). Let the blastoderm grow still farther, and the mass will be found

to increase in length (Fig. 59, Pl. XCV, median longitudinal section through a stage something younger than Fig. 38, Pl. XCII). In transverse sections the exact relations of this mass are made clear. It is then seen that in the posterior half of the apparently homogeneous mass (*c. m.*) there is no differentiation of layers at all, but in the anterior half the condition is such as is shown in Fig. 60, Pl. XCV. The posterior region. in which there is absolutely no differentiation, will be spoken of as the caudal mass (bourgeon caudale, schwanzknospe), while the anterior region, in which there is fusion between the neural chord and the entoderm, may conveniently be called the neurenteric streak. The whole tract from the termination of the notochord to the end of the embryo has been regarded by Henneguy (18) and Schwarz (39) as a primitive streak analogous to the streak of Amniota, and (Schwarz) homologous with that of Amphibia. I fully agree with these views and will use the term primitive streak in this meaning. The name neurenteric streak implies that it is in this region that the neurenteric canal belongs, or would belong if it ever came into existence. As to this location of the neurenteric canal most students are agreed. (See especially Henneguy, *l. c.*, and Schwarz, *l. c.*)

During the further growth of the blastoderm round the yolk the primitive streak may increase in length (*pr. str.* Fig. 65, Pl. XCVI, a median longitudinal section just before the closure of the blastopore), but the increase is scarcely measurable.

Before discussing the way in which the primitive streak is established, a word may be said on the condition in the *Salmonidæ*. There here appears to be from the start, *i. e.*, before the blastoderm has begun to encircle the yolk, a very considerable caudal mass (bourgeon caudale, schwanzknospe), and Henneguy, *l. c.*, p. 585, has satisfied himself that in the trout the region of the primitive streak does not increase appreciably in length during the closure of the blastopore. Now, in spite of the fact that embryos vary considerably in length, and exact measurements can not therefore be implicitly trusted, it is unmistakable that in the Bass the primitive streak suffers a considerable increase in length during the closure of the blastopore. When the rapid growth of the blastoderm begins there is really no bourgeon caudale (Fig. 44, Pl. XCIII), but by the time the yolk is half encircled there is a perceptible bourgeon (caudal mass), from which the fusion extends forwards in the median line (Fig. 49, Pl. XCIV, transverse section through the anterior part of the primitive streak). Still later (Figs. 36, Pl. XCII, and Fig. 55, Pl. XCV) the primitive streak has slightly increased in length, and in the yet later stages (Fig. 59, Pl. XCV, and Fig. 65, Pl. XCVI) its increase in length is unquestionable.

The apparent difference between the Trout and the Bass in this matter may not after all be so great as it would seem. Without going into a further comparison, however, I feel bound to regard the Bass development as the more typical, if only for the reason that it is as regards this point so easily harmonized with the Amphibian development.

The means by which the primitive streak is brought into existence is obvious. As the blastopore grows smaller the extra embryonic part of the germ ring is *pari passu* drawn into the tail end of the embryo, and there is thus built up in this region a constantly increasing mass of undifferentiated cells. As this mass is built up the mesoderm plates cut their way back, and thus give rise in the anterior part of the region to what I have called the neurenteric streak. In the Bass there is no actual concrescence in the middle line (see surface view of closing blastopore, Fig. 39, Pl. XCIII), but the terminal notch observed in some fish, as well as general considerations derived

from a comparison of Teleosts with Amphibia, warrant us in regarding the closure of the blastopore as a process of concrescence, the result of which is to establish the primitive streak. Schwarz has come to the same conclusion (29).

At the final moment of the blastopore closure there is added to the primitive streak the mass of cells, *sec. c. m.*, Fig. 65. This mass is of course the remnant of the extra-embryonic germ ring. Even after its fusion with the primitive streak, a dividing furrow makes it for some time recognizable. It may be called, for convenience of reference, the secondary caudal mass.

The entire mass of undifferentiated cells left at the tail of the embryo after the blastopore closes, serves as cellular material for the backward growth of the several organs. Thus, while the extra-embryonic germ ring, as has been insisted upon by Agassiz and Whitman (*l. c.*) and Cunningham (8), assuredly forms part of the embryo, it does not form any special part, but, on the contrary, its cells eventually find their way into ectodermic, mesodermic, and notochordal tissues.

The behavior of the periblast during the final moments of blastopore closure may be gathered from Fig. 65, Pl. XCVI. As will be seen, the periblast closes over the blastopore area before the blastoderm proper. After the closure the periblast plug (*p. pl.*) disappears, the layer forming an even and complete investment of the yolk.

Entoderm.—After this digression the early history of the secondary layers and the notochord may be resumed. Four hours later than the stage last described (Fig. 36, Pl. XCII, and Fig. 56, Pl. XCV) the entoderm is completely established as a connected unicellular layer. In sections through a small embryo like the Bass it is often impossible to decide whether the entoderm on each side grows under the notochord, as shown in Fig. 56, or whether it is split off from the base of the group of chorda cells. In order to reach a decision I was forced to cut a great number of sections, for it is only now and then that one is obtained in which all the lower cells are clearly defined. In the sections through the stage of 25 hours (Fig. 37, Pl. XCII, and Figs. 55 and 56, Pl. XCV) the extremely intimate connection between the entoderm and chorda was uniformly evident, and in some sections, for instance the one given in Fig. 56, it was incontestible that the entoderm was actually growing under the chorda cells. The exact state of affairs in the earlier stage (Fig. 53, Pl. XCIV, and Fig. 54, Plate XCV) was likewise often difficult to determine, but the best sections were such as I have drawn. After a careful study I feel safe in saying that the lateral sheets of entoderm grow under the chorda cells and meet in the middle line, thus completing the layer. Agassiz and Whitman state the same for *Ctenolabrus*. In the Trout, according to Henneguy (18), this method is not followed. The primitive hypoblast there breaks up into mesoblast, notochord, and definitive entoderm, the entoderm being from the first continuous across the median line. The condition in the Trout is of course a derived one, while the development of the Bass in this matter closely follows the ancestral lines: the chorda cells at first actually roof in the archenteron along the median dorsal line, as in *Amphioxus* and Amphibia.

The entoderm, after it has grown under the chorda, is shown in the longitudinal section, Fig. 59, Pl. XCV, and in the transverse sections, Figs. 60, 61, and 62, Pl. XCV, all from the same stage (29 hours). The cells of which the layer is composed are flattened except at the posterior end of the embryo, in the region of the neurentric streak (Fig. 60, Pl. XCV, and Fig. 59, Pl. XCV, *n–m*). Since the notochord does not extend into this region, it is evident that the entoderm cells here must have had a different mode of origin from that employed along the notochordal tract; and in fact they are merely

the lowest cells of the streak which have assumed a columnar shape, and have thereby differentiated themselves from the rest. The line of demarcation between them and the neurenteric streak is always more evident in transverse than in longitudinal sections.

Posteriorly they, together with the mesoderm and ectoderm, fade away into the caudal mass (Fig. 59, behind *n*). Anteriorly they are continuous with the flat entoderm. These columnar cells subsequently form the roof and walls of Kupffer's vesicle.

Brook (3) has tried to show that the entoderm lamella, instead of delaminating from the invaginate germ ring, is derived from the periblast. Kupffer has always maintained that the periblast is the source of the entoderm (24, 25, 26); but it seems impossible that this should be the case in any Teleost, when so many observers have failed to find that the periblast takes any share in forming the permanent layers.

Notochord.—By the time the entoderm layer is completely established the notochord has assumed its ultimate shape of a somewhat cylindrical rod. (Fig. 61, Pl. XCV, *n. c.*) Anteriorly it thins away (Fig. 62, Pl. XCV) and in the neck region disappears. The two layers of polygonal cells which primitively constituted the chord (Figs. 55 and 56, Pl. XCV) have in Fig. 59, Pl. XCV, begun to assume the well-known shape characteristic of chorda cells. They are already much interlocked, and a few hours later (Fig. 65) each cell, in a longitudinal section, extends the whole width of the chorda. In the early stages of the chorda the number of cells which together compose a cross section (Fig. 61) is much greater than in later stages. For, as the cells become flattened antero-posteriorly, they spread out in the transverse plane, and consequently two or three come to compose a cross section (Fig. 77, Pl. XCVII, 39 hours). When this stage is reached it is next to impossible to determine the cell outlines.

The next stage in the histological differentiation of the chorda is brought about by vacuolation. The beginning of vacuolation is shown in Fig. 110, Pl. CI (transverse section through an embryo of 53 hours). The vacuolation continues until, before the time of hatching, the protoplasm is reduced to a thin peripheral layer (Fig. 127, Pl. CIII), in which the nuclei are situated, and a few strands which cross the central cavity. By this time a well-defined sheath of high staining power is found round the chorda. After hatching the sheath becomes more conspicuous and the protoplasmic layer even thinner than before. (Compare Fig. 144, Pl. CV, part of a transverse section through a larva 3 days after hatching. The notochordal sheath is indicated by a heavy line, *n. c. s.*)

The vacuolation which probably puts an end to cell multiplication, does not extend into the posterior portion of the chorda. The chorda cells on the contrary retain in this region their embryonic, protoplasmic character. Compare Figs. 111 and 114, Pl. CI, transverse sections through the tail and head regions, respectively, of an embryo 59 hours old, and Fig. 119, Pl. CII, through the tail of a 65-hour embryo. At the tip of the tail there is found throughout embryonic life and for 3 days after hatching (possibly for a much longer time) a mass of undifferentiated cells (caudal mass) in which the chorda ends. At the time of hatching this mass of cells has become very small. The posterior growth of the chorda undoubtedly depends upon the presence of these undifferentiated cells, and possibly upon the embryonic character of its own cells in this region, though I have not observed nuclear figures.

If a comparison be made between Fig. 53, Pl. XCIV, and Fig. 83, Pl. XCVIII, it will be evident that a considerable forward extension of the chorda takes place after the

early stages in its formation. The amount of forward extension will, however, be overrated unless it be borne in mind how much greater the ratio of the brain region to the trunk is in the earlier stages than in the later.

Mesoderm.—The history of the mesoderm may here be conveniently carried up to the closure of the blastopore. The condition shown in Figs. 60, 61, 62, 63, 64, Pl. XCV and XCVI (successive sections from same embryo, 29 hours), is practically retained until the closure. The mesoderm now throughout the trunk consists of two thick lateral masses (Figs. 60 and 61, *mes.*), thinning away at the sides, but not exhibiting the two-layered arrangement which in the trout prefigures the differentiation of somatopleure and splanchnopleure. As will be seen in the sequel, the development of the body cavity in the Bass is secondarily modified in a high degree. The cells of the mesoderm plates are polygonal except at the surface, where they now begin to assume a columnar shape which later becomes more pronounced.

The mesoderm plates fade away as they reach the neck region, here giving place to scattered mesoblast cells (Fig. 62). In the posterior head region there are a few scattered cells (Fig. 63) and a rather well-marked layer (*en. mes.*) which posteriorly is continuous with the entoderm, and anteriorly breaks up into scattered mesoblast cells, which form a loose investment of the eye-balls and brain. The layer in question is no doubt in great part entodermic, but it is impossible at this stage to fix upon the precise spot at which the entoderm lamella ceases and the scattered mesoderm begins. All we can say is that in the anterior brain region (Fig. 64, Pl. XCVI) the primitive hypoblast becomes entirely converted into mesoblast. The anterior mass of mesoderm cells (*a. m.*, Fig. 55) disappears at about this time, its cells apparently migrating and sharing in the general investment of the brain.

Formation of the mesoderm in Teleosts and the Cœlom theory.—It has been universally recognized by students of the Teleosts that the mesoderm originates by delamination. It seems likewise certain that the primitive method of forming the mesoderm in the Chordata was by the outgrowth of paired sacs from the dorso-lateral walls of the archenteron. According to Balfour's idea of the cœlom theory there was no contradiction between the two facts. As is well known, he believed that in the Selachians the mesoblast was delaminated as two lateral masses (more recent investigations would seem to show that it arises as paired outgrowths, Rabl, 38), but that the delamination was the cœnogenetic representative of an original outgrowth. He was thus thoroughly convinced that evagination could be, and was, in certain vertebrates, replaced by delamination.

The cœlom theory of Hertwig as applied to the vertebrates is, however, of a different type. According to Hertwig not only has the method of forming the mesoderm in the various vertebrate groups been derived from the primitive method shown in *Amphioxus*, but in the ontogeny of all vertebrates it still follows the ancestral lines in the one essential point: the mesoderm arises as paired *outgrowths* from the walls of the archenteron. Hertwig has himself shown that the cavity of the sac may be obliterated and the outgrowth in consequence be solid, but he is convinced that the process is always one of outgrowth and never of delamination. His position is sharply defined in the following quotation:

> Bei keinem der Wirbelthiere entsteht der Mesoblast durch Abspaltung, sei es vom äusseren, sei es vom inneren, Grenzblatt, da er von beiden mit Ausnahme eines sehr beschränkten Keimbezirkes, überall durch einem Spaltraum scharf abgegrenzt wird (20, p. 308).

In the Amniota there is such divergence of opinion as to the precise way in which the mesoderm originates that Hertwig is able to defend his position with some success from this quarter (20). But in the case of the Teleosts there is such remarkable agreement in the descriptions of the way in which the mesoderm is formed that Hertwig's theory must, I think, be regarded as in opposition to the facts. The conclusion is forced upon us that in certain vertebrates evagination has been replaced by delamination in the formation of the mesoderm.

Accepting this conclusion, we naturally look about for a type which suggests a transition from the one method to the other. In looking over the figures with which Hertwig illustrates the development of the mesoderm in the frog (20, 1882), the suggestion that there is here a partial delamination strikes one strongly, and is worth a word or two. In *Triton*, according to Hertwig, the invaginate entoderm or chorda-entoblast is wholly used in forming the chorda. The wall of the gut is formed exclusively by the darm-entoblast. In the frog, on the contrary, the invaginated layer is a wider as well as thicker one, and not only forms the chorda but also a part of the roof of the gut (Fig. 5). In the figure, a transverse vertical section, the invaginated

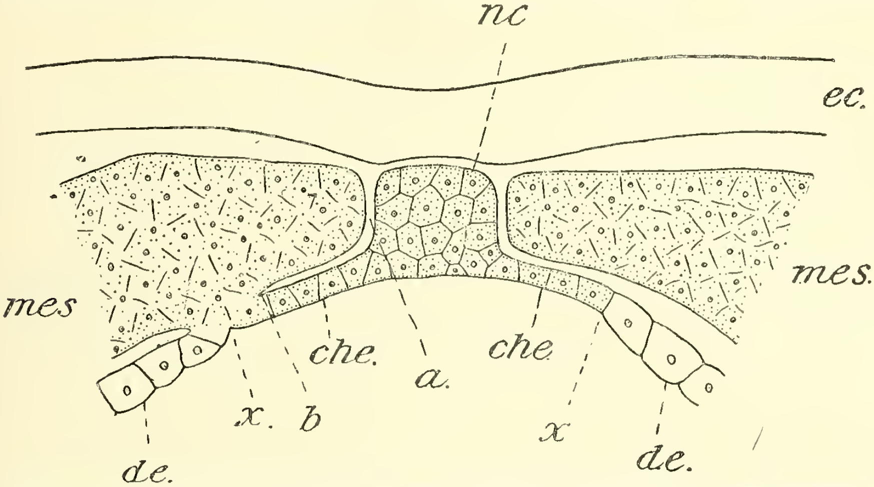


FIG. 5.—(after Hertwig, 20). Transverse vertical section through frog embryo to show partial delamination of mesoblast—*ec.*, ectoderm; *nc.*, notochord; *mes.*, mesoblast; *ch. e.*, chorda-entoblast; *d. e.*, darm-entoblast; *a.* to *b.*, delamination fissure; *x.* to *x.*, junction of chorda-entoblast and darm-entoblast.

layer is supposed to extend from x to x, at which points the chorda-entoblast, *ch. e.*, and the darm-entoblast, *d. e.*, pass into the mesoblast, *mes.* Now the figure, as far as it is possible to interpret it without having studied the previous stages, indicates that the invaginated layer in an earlier stage formed a continuous mass, stretching from x to x, and of about the thickness of the notochord. This mass appears to have broken up into notochord, chorda-entoblast, and the proximal parts of the mesoderm plates (from a to b). If this interpretation of the figure is a true one, and I am unable to understand the figure on any other supposition, then the mesoblast has delaminated from the notochord to x. The further growth of the mesoderm, peripherally from x, doubtless takes place as Hertwig describes.

It is very clear that in the frog the development of the derivatives of the primitive hypoblast does not take place in the simple ancestral manner shown in *Amphioxus* and *Triton*. The invaginate layer is made a thick one, so that the chorda is not forced

to come slowly into existence through a process of folding, but is at once cut out of a preformed mass of material, and, as I have said, I am inclined to believe the same is true of the proximal parts of the mesoblast plates. Indeed, Hertwig seems to entertain much the same idea when he speaks of the way in which the chorda and chorda-entoblast are separated from the mesoblast. Only he views the process from a different standpoint, and so compares the delamination fissure (*a* to *b*, Fig. 5) directly with the dorsal fold which lies between the outfolding notochord and mesoblast sheet of *Triton*.

If, now, the invaginate entoderm, which in the frog forms only a part of the roof of the alimentary canal, should take upon itself to form gradually more and more of the alimentary canal, it would probably from the very beginning become wider: the space from *x* to *x* would increase in width. The increase in width would naturally bring it about that a much larger part of the mesoderm plate would be delaminated than was formerly the case; there would constantly be less and less of the mesoderm which would have to arise as an outgrowth. Finally the condition in the Teleost would be reached, in which the mesoderm plate is split off from the primitive hypoblast along its whole width.

V. FORMATION OF THE ALIMENTARY CANAL.

The alimentary canal is formed from the simple entoderm lamella by a process of folding along the median line (Fig. 76, Pl. XCVII). The fold is converted into a tube by the meeting of its lower edges. There is a solid postanal gut formed as a thickening of the entoderm lamella, not as a fold. At the end of the postanal gut is Kupffer's vesicle, which is formed in essentially the same way as the permanent alimentary tube. It is scarcely necessary to say that Kupffer's vesicle and the entire postanal gut atrophy.

It seems worth while to give a detailed description of the formation of the alimentary canal, and this will best be done by going methodically through the several stages, taking up each series of sections at the posterior end of the embryo and passing forward.

The formation of the alimentary canal begins first in the region of Kupffer's vesicle and very shortly afterwards in the branchial region. Some hours before the closure of the blastopore the entoderm cells of the neurenteric streak (*n. str.*) become columnar (Fig. 60, Pl. XCV). These cells subsequently inclose Kupffer's vesicle. The rest of the entoderm lamella in this stage is made up of flattened cells.

Stage of 35 hours (Fig. 65, Pl. XCVI, and Figs. 66 to 72, Pls. XCVI and XCVII, series of sections from the same embryo). At the time when the blastopore closes sections through the neurenteric streak show an early stage in the formation of Kupffer's vesicle. The columnar entoderm cells have been pushed up in the middle line (Fig. 66), and arch over the cavity of the vesicle (*k. v.*), the floor of which is formed by the periblast. The vesicle is in this stage broad and shallow. Posteriorly the cavity fades away (longitudinal section, Fig. 65), and anteriorly likewise. The lining cells of the vesicle are directly continuous with the entoderm lamella. Passing forward (Figs. 67 and 69) the entoderm of the trunk is found to be thicker in the median line than laterally, the cells under the notochord approaching a columnar shape. Another feature will be noticed on comparing Fig. 67 with a section through an earlier stage (Fig. 61, Pl. XCV). The whole embryo is growing deeper and narrower, and coincidently

with this change in shape the entoderm is being drawn away from the sides towards the middle. This contraction of the entoderm towards the axis of the embryo becomes more apparent in later stages.

In this stage there is no trouble in discerning the precise anterior extent of the entoderm. In front of the medulla (*med.*, Fig. 147, surface view, of about same age as the sections we are now examining) there is scattered mesoderm but no entoderm. The transverse section, Fig. 71, through the middle of the branchial region, lies about in the plane x of Fig. 147. In this region the entoderm does not thicken in the middle line, but along two lateral lines (*br. f.*, Fig. 71), which in going back towards the posterior limit of the branchial region approach the middle. Along these lines the columnar cells have already begun to rise up in the shape of lateral folds (*br. f.*).

Stage of 39 hours (Figs. 73 to 79, Pl. XCVII, series of sections). In this stage Kupffer's vesicle is nearly as shallow as in the last, but its lateral limits (*m–m*, Fig. 73) are more sharply marked than was the case in Fig. 66. This is due, as the direction of the cells and subsequent stages show, to the fact that the entoderm cells at *m–m* have begun to grow towards the middle line. The formation of Kupffer's vesicle is a true process of folding quite like the formation of the alimentary tube in the trunk. There may be one point of difference which concerns the lateral entoderm (*l. en.*, Fig. 73). In the trunk the whole entoderm lamella is contracted towards the middle line and used up in forming the tube; but in the region of Kupffer's vesicle the lateral entoderm at least retains for a long time its original extent, while growing very thin. I am inclined to believe that the lateral entoderm is not drawn into the walls of the vesicle as it is into the walls of the gut, but that after becoming an excessively thin membrane it is absorbed in some other way. In a slightly later stage (41 hours) than the one just described the lateral entoderm has disappeared (Fig. 82, Pl. XCVIII). In this stage the increase in height and diminution in width of the vesicle, in consequence of the progress of folding, will be apparent.

Anterior to Kupffer's vesicle there is a median tract of thickened entoderm (transverse section, Fig. 74, *en.*) most of which will never be folded off, but will form the postanal gut. The anterior portion of the tract will, however, form a fold, and the axial cells in Fig. 74 have the typical arrangement and shape which precede its first appearance. Farther forwards there is a well-marked furrow (Fig. 75) which reaches its greatest height in about the middle of the trunk (Fig. 76). The distinctness of the cell outlines enables us to get at least a superficial insight into the process by which the furrow is produced. On comparing the three stages, Figs. 74, 75, and 76, there seems to be very little if any cell multiplication; no nuclear figures were observed. The cells on each side of the median line early exhibit a tendency to grow towards the axis; and in a general way, the process may, I think, be described as follows: In Fig. 74 the inner and lower ends of the cells 2, 2, grow towards the axis, and in so doing lift up the cells 1, 1, thus establishing an extremely minute cavity between them and the periblast. It is possible to follow every stage in the formation of the cavity from its first appearance as a minute, almost round aperture to the condition shown in Fig. 75. The cells 3, 3, follow the example of their predecessors, and thus the keystone cells 1, 1, are lifted still higher above the periblast. Let this course of action be followed by the cells 4, 5, etc., and it is easy to understand how the arch is increased in height, and at the same time how the lateral entoderm (*l. en.*, Fig. 74) disappears (as it has in Figs. 75 and 76); its cells, one after another, slip under their axial neighbors towards the median line.

The cell outlines in the several stages of the furrow, which I have tried to reproduce exactly in the figures, indicate that the method just described is the one followed, but complications undoubtedly supervene; for instance, the gut is often closed in ventrally before all the lateral entoderm has been drawn into its wall (Fig. 93, Pl. XCIX). Exactly how the cells thus left out disappear I do not know. In some cases, it would seem, they force their way between the cells which already line the tube, but again their position indicates that they are merely absorbed. In general, the method of forming the gut may be spoken of as a modification of the ordinary process of folding, such as is made use of in the Amniota, its peculiarity depending on the fact that the lateral entoderm is employed in helping to form the tube.

The condition in the branchial region is shown in the transverse section, Fig. 79, Pl. XCVII. If this figure be compared with the earlier stage, Fig. 71, Pl. XCVII, the course of development will be evident. The lateral folds (*br. f.*), barely begun in Fig. 71, are now well marked out. The further development of this tract of the enteron may be indicated in a few words. The apex of the fold, *a*, grows dorsally and ultimately fusing with the ectoderm, there is thus established the embryonic gill slit (only one in the embryo). The base, *b*, grows towards the median line and, meeting its fellow of the opposite side, closes in the foregut ventrally. As to the fate of the lateral entoderm of this region, I have not been able to come to a decision.

In passing backwards from Fig. 79 the lateral branchial folds gradually die out, Fig. 78, and in so doing approach the median line, where, in the œsophageal region (Fig. 77), they give place to a single broad low arch. The low œsophageal arch passes gradually into the deeper trunk furrow of Fig. 76.

Stage of 45 hours (Figs. 83 and 84, Pl. XCVIII, and Figs. 88 to 95, Pl. XCVIII and XCIX, series of sections). In this stage the tail begins to develop. The furrow, *t. f.*, which marks it off is shown in the longitudinal section, Fig. 84. Kupffer's vesicle in many individuals of this age is still bounded by the periblast, as in the longitudinal section, Fig. 84. In others, however (transverse section, Fig. 88), the process of folding has been completed, and the vesicle has an entire cellular wall; the lower edges of the fold, *m–m*, Fig. 82, have met in the middle line and closed in the vesicle ventrally.

In front of Kupffer's vesicle stretches the postanal gut (*p. a. g.*, Fig. 84), a mere thickened stripe of entoderm. At its posterior limit, just in front of the vesicle, at *r*, Fig. 84, it is fused with the notochord. A transverse section through this region of fusion is given in Fig. 90.

Directly in front of the postanal gut, at about *a*, Fig 84, a short tract of entoderm is found, in the condition shown in Fig. 91. This is the region of the anus, and the fold here appears last of all. In front of the anal region there is still for a short distance an open furrow, Fig. 92, but in the rest of the trunk and in the branchial region the enteron is now closed ventrally. The closure begins anteriorly and travels back. Figs. 93 and 94, Pl. XCIX, are through the trunk region. In the latter figure the remnant of lateral entoderm has finally disappeared. In the œsophageal and branchial regions the cavity of the enteron is almost obliterated. Fig. 105, Pl. C, is through the œsophagus (*oes.*) of a later stage than the one now under examination. Fig. 95, through the branchial region, is slightly oblique, and therefore it is only on one side that the gill slit is shown. In forming the gill slit the entoderm becomes continuous with the nervous layer of the ectoderm, as shown in the figure, while the epidermic stratum at first remains unbroken, dipping slightly into the branchial cavity.

Subsequently this stratum is perforated and a true opening is established. After the opening is once established there is formed round it a shallow depression of the general surface, so that in transverse sections the opening comes to be funnel-shaped (*g. s.*, Fig. 114, Pl. CI). The external appearance of the gill opening may be gathered from Figs. 149 and 150, Pl. CVII, *g. s.* As I have said, there is but this one opening into the branchial chamber during embryonic life. The remaining gill slits appear a day or two after hatching in front of the embryonic slit, but I have not studied their mode of formation.

Postanal gut.—In the stage which has just been under examination the tail had barely begun to develop. A few hours later (surface view from below, Fig. 98, Pl. XCIX), it becomes a prominent feature, and in the course of its development comes to contain the greater part of the postanal gut (*p. a. g.*). In this stage (Fig. 98) the cavity of Kupffer's vesicle has entirely disappeared. Indeed the cavity disappears in a much earlier stage of the development of the tail, as will be seen in Fig. 89, Pl. XCVIII, which is from a stage but slightly more advanced than Figs. 88 and 84, Pl. XCVIII. The obliteration of the cavity is brought about by the proliferation of the cells of its own wall. After the disappearance of its cavity Kupffer's vesicle is not distinguishable from the rest of the postanal gut, which at its posterior end gradually increases in size (Fig. 98) before vanishing in the caudal mass. The transverse sections, Figs. 99 and 100, Pl. XCIX, and Fig. 102, Pl. C, are all from an embryo nearly like Fig. 98. The two former sections show the condition of the gut within the tail, while Fig. 102 shows the condition of the tract *p. a. g.*, which the folding off of the tail has not yet reached. Referring them to Fig. 98, Fig. 99 lies in the Plane 1, Fig. 100 in Plane 2, and Fig. 102 in Plane 3. The position of the anus (not yet broken through) in the surface view is at *a.* Fig. 99 occupies the same relative position that Fig. 90 had in an earlier stage, is just in front of the neurenteric streak, and the entodermic mass, *p. a. g.*, is composed of the fused postanal gut and notochord. In Fig. 100 the postanal gut and notochord are separate. In front of the tail, Fig. 102, the postanal gut, *p. a. g.*, is less massive than farther back.

The postanal gut reaches the height of its development in the stage shown in Fig. 98. Almost immediately atrophy sets in. The atrophy begins at the anterior limit of the tail, and travels backwards and forwards. The sections, Figs. 99, 100, 101, and 102, are from an embryo in which the atrophy has just begun, and Fig. 101 is through the place where it starts. As will be seen in this figure, the atrophy of the gut leaves certain cells to mark its former position. These cells will again be touched on in dealing with the subnotochordal rod, the caudal extension of which they represent. The same cells in a later stage and farther back in the tail are again shown in Fig. 109, Pl. C, and Fig. 111, Pl. CI, *s. n. r.* The last part of the postanal gut to disappear is its swollen end.

Subsequent history of the alimentary canal.—The formation of the anus takes place before hatching, and there seems to be no ectodermal invagination to form a proctodæum. The mouth breaks through a couple of days after hatching. Shortly after the mouth appears, the cells which line the alimentary canal lose their embryonic appearance and come to look much like an adult mucous membrane; they secrete a cuticle and their limiting surface is no longer smooth (Fig. 144, Pl. CIV, *al. c.*). In the just-hatched larva, the condition of the alimentary canal in that part of the trunk which has been folded off from the yolk is shown in Fig. 126, Pl. CII.

Liver.—The formation of the liver begins about a day after hatching. It arises as a solid outgrowth from the dorsal wall of the enteron not far behind the limbs. Its condition in this stage is shown in Fig. 138, *l*, Pl. CIV (part of a transverse section through a larva 100 hours old). The cells of the solid outgrowth very soon arrange themselves so as to form the walls of tubes (Fig. 140, *l*, Pl. CV, larva of 112 hours). As the liver increases in size it grows down between the ectoderm and the yolk sac (Fig. 141, Pl. CV, 136 hours), to the posterior wall of which it henceforth clings.

A word may here be said as to the general characteristics of the larvæ in which the liver has become prominent. The yolk sac is now so small (Fig. 141) that it is limited to the anterior part of the trunk. The periblast layer still forms, as in earlier stages, a protoplasmic stratum clearly marked off from the yolk. The ventral surface of the yolk sac is closely pressed against the ectoderm, but elsewhere the ectoderm is separated from the rest of the embryo by a wide space (*b. si.*, Figs. 141 and 143). This space, which may be called the body sinus, is filled with a gelatinous fluid, which coagulates into a loose, stringy mass much like (only less dense than) the jelly of a medusa bell. After coagulation the jelly exhibits an irregularly radial arrangement. The body sinus is apparent in embryos just hatching, but the fluid which fills it does not develop its peculiar qualities until much later.

The further growth of the liver is connected with the final disappearance of the yolk and periblast. The three transverse sections, Figs. 143, 144, and 145, Pl. CV (from a larva 160 hours old), show how this disappearance is brought about. In the posterior section (Fig. 143) the connection of the liver with the alimentary canal is shown. The only part of the yolk which extends this far back is a vesicle, *o. g.*, which I take to be the oil globule. The oil globule has long before this (Fig. 151, stage of 65 hours), become intimately associated with the periblast, the protoplasm of which has grown entirely round it. In the two anterior sections (Figs. 144 and 145) the intimate connection between the liver (*l*) and the yolk (*y*) is obvious. The periblastic protoplasm, which in earlier stages formed a definite peripheral layer is now diffused through the yolk, which, in consequence, takes the stain. The yolk does not stain very deeply, but the contrast between its present and former condition is sufficiently striking. The periblastic nuclei have also undergone a change. They are no longer flattened and they stain much more uniformly than in earlier stages. Some of them have even a single nucleolus, and between such nuclei and the nuclei of the liver cells there is but very little difference. They are also no longer exclusively confined to the periphery of the yolk. The outlines of the liver cells adjacent to the yolk can not be made out. From these facts it is very evident that the liver is absorbing the yolk and periblastic protoplasm. The process is probably akin to ordinary intracellular digestion, but I could not discover the existence of any pseudopodia, nor do I believe that any such exist. As well as I could interpret the sections the process is something as follows: After the protoplasm has diffused through the yolk, the adjacent liver cells become actually continuous with this deutoplastic protoplasm. The cells which thus establish a connection with the yolk form a feeding or absorbing surface, which, as it incorporates new material on its yolk side, as constantly splits off new cells from its liver side. In this way the mass of yolk protoplasm shown in Fig. 145 is, bit by bit, entirely converted into liver cells. The precise fate of the periblastic nuclei I have not determined. That they, even in a slight measure, regain their early condition is

a matter for surprise. They probably in the end lose their identity and are absorbed as so much food material. Certainly there is no ground for believing (in the Bass) that they become blood corpuscles.

Historical.—In pelagic eggs the alimentary canal has usually been supposed to originate as a solid thickening of the entoderm lamella (Ryder 34, Kingsley and Conn 28, Agassiz and Whitman 1, Cunningham 8). Cunningham concluded that the ventral part of the thickening (floor of canal) was formed from periblastic elements, which migrated out of the yolk; but the grounds for this conclusion were very inadequate.

The formation of the canal in the trout has been studied in greater detail. From Oellacher's paper (33) it is difficult to arrive at a decision as to its exact mode of formation. Hoffmann (17), however, distinctly states that the process is one of folding, but aside from the branchial region his description is scarcely detailed enough to give one a satisfactory idea of the matter. Ziegler (48) and Henneguy (18) both describe the canal as arising in the main as a fold, and compare the process with the corresponding phenomenon in the Amniota. Henneguy's description is the more detailed of the two, and is no doubt in the main accurate for the trout. According to Henneguy, in the anterior part of the trunk behind the branchial region the canal is formed as a thickening which subsequently becomes hollow. In the rest of the trunk there is a median fold, the walls of which are so appressed that the cavity is a virtual one. Henneguy, however, does not speak of the postanal gut, and believes that the cavity of Kupffer's vesicle is continuous with that of the intestine: "La vesicule de Kupffer n'est donc que la premiere apparition de la cavité du tube digestif avec laquelle elle se confond plus tard" (*l. c.*, p. 563, Fig. 109, Pl. XXI). This can scarcely be so, for Schwarz's sections (39) prove the presence of a solid postanal gut in the trout, which subsequently atrophies together with Kupffer's vesicle.

Kupffer's vesicle.—The discovery of this vesicle was made by Kupffer in 1868 (24), and since then it has occupied a conspicuous place in the embryology of Teleosts. Its formation has never been satisfactorily worked out, and it has hence given rise to more discussion than could justly be claimed by it. The discoverer of the vesicle believed that it arose as an ectodermic invagination from the dorsal surface (25, 26), and in his figures the vesicle is shown as such a sac, closed below and opening on the dorsal surface. In his general scheme of vertebrate gastrulation Kupffer makes this sac play an important part. He regards it as homologous with the dorsal invagination of Reptilia, which he believes (26) constitutes the allantois (and part of rectum). The vesicle is then, for Kupffer, a structure which in higher groups becomes the allantois. From this standpoint it is a little misleading to speak of it as a rudimentary allantois, as is commonly done. It is rather a "prophetic" allantois. However, no one has ever confirmed Kupffer's account of the way in which the vesicle is formed, and until that is done it would scarcely seem possible to entertain any homology between the vesicle and the invaginated pit of reptiles.

Other investigators who have discussed this point of Teleost development depart widely from Kupffer's account, but differ among themselves. On the one hand Kingsley and Conn (28), Agassiz and Whitman (1), Cunningham (9), state that the vesicle arises as a space between the entoderm proper and the periblast. Henneguy (18) and Schwarz (39), on the other hand, contend that from the start the vesicle has a cellular floor, and arises as a closed cavity amongst the cells in front of the caudal mass. It will be noticed that the former group of investigators all worked on pelagic

eggs, while the latter two arrived at their conclusions from a study of the *Salmonidæ* (Schwarz also worked on the Pike). I have found that in regard to the point mentioned the former investigators were right—the cavity of the vesicle originally lies between the entoderm and the periblast.

The essential agreement, however, between the accounts of Henneguy and Schwarz leads one to believe that in the *Salmonidæ* the development of the vesicle may have suffered secondary modification. Whereas in the Bass the vesicle arises by a process of folding, in the *Salmonidæ* its development may be construed as the hollowing out of a solid thickening. After the vesicle has become a closed sac its further development and relations to the postanal gut have been correctly described by Schwarz.

Significance of the vesicle.—The significance of the vesicle is linked with the interpretation of the gastrula, which the vesicle on its side elucidates. In regard to gastrulation I am in thorough accord with Ziegler (48), and therefore regard the space (in great part virtual) between the entoderm and the periblast as the archenteron. The entoderm represents the dorsal hypoblast of the gastrula, the yolk and periblast the ventral hypoblast, and it is from the dorsal hypoblast alone that the alimentary canal is formed. The alimentary canal is formed by a process of folding, and Kupffer's vesicle, as the terminal part of the (postanal) gut, follows the same method. After the gut has been once folded off, the homology of the vesicle with the postanal vesicle of Selachians (instituted by Balfour in his text-book) is obvious. In each group the vesicle forms the dilated extremity of the postanal gut, and receives, or would receive if it existed, the neurenteric canal. But I think the homology is just as evident in the early stages of Kupffer's vesicle, as soon as it is recognized that the space between the entoderm and the periblast is the archenteron. In Fig. 65, Pl. XCVI, Kupffer's vesicle, *k. v.*, represents the dilated terminal portion of the archenteron, while in Fig. 88, Pl. XCVIII, it is the posterior end of a gut which has been folded off from the archenteron. The postanal vesicle of Selachians represents both. It forms the end of a gut produced in great part by folding, and it unquestionably represents the terminal portion of the archenteron.

But if Kupffer's vesicle in its early stages (Fig. 65) indicates that the terminal portion of the archenteron was primitively dilated, we naturally inquire both for the cause and for a corresponding phenomenon in the ontogeny of those animals in which the archenteron is bodily transformed into the permanent gut. As to the latter point, it would seem very common in the Amphibia for the archenteron to be thus dilated (see Morgan's figures, 32, and Götte's figure, Balfour, T. B., vol. 2, p. 105). The existence of such a dilatation in the enteron of primitive Chordata is further made probable by, and receives an explanation from, the relation of the neurenteric canal to the blastopore.

Morgan (32) has shown that in *Amblystoma*, after the neurenteric canal has been established by the closure of the upper part of the blastopore, the lower part of the blastopore remains as a common opening for the rectum and neural tube (persisting as the permanent anus). This condition he believes existed in adult early Chordata. Cunningham (8) advances a similar suggestion, and I see no reason for rejecting the idea. In the hypothetical animals which once existed with this arrangement of parts it is highly probable that the extreme end of the rectum into which the neurenteric canal opened was dilated into a kind of cloaca. And it is this cloaca which is represented in the ontogeny of vertebrates by the terminal dilatation of the postanal gut.

Balfour (T. B., vol. 11, p. 268) was the first to make this suggestion, though in a slightly different form; for being at that time unaware of the persistence of the blastopore in certain animals as the anus, he concluded that the common cavity (cloaca) was only established after the entire closure of the blastopore.

It will be seen that in the interpretation of Kupffer's vesicle I substantially agree with Cunningham (9)—it is the terminal part of the archenteron. Its significance is indeed a mere corollary of Ziegler's general interpretation of the Teleost gastrula, but on its side its existence strengthens this interpretation; for the presence of such a conspicuous cavity between entoderm and periblast can only be explained on the supposition that the space (virtual or real) between entoderm and periblast represents the archenteron.

It only remains to speak of the neurenteric canal. Various solid cords of cells have been spoken of by writers, which have been construed as representing this canal. These cords, however, have all been very ill defined and have not been represented in figures. Moreover, they have been found in entirely different places. In the Bass I have not succeeded in finding anything which could be interpreted as a neurenteric canal, nor do I believe that any representative of it exists. It is generally recognized that if the canal were present, it would open into Kupffer's vesicle. This is evident from the existence of the neurenteric streak (Fig. 82, Pl. XCVIII, *n. str.*). The canal could not, of course, open in front of the streak, and behind it the neural chord is not distinguishable from the mesoblast; or, in other words, just behind the neurenteric streak and Kupffer's vesicle lies the caudal mass of undifferentiated cells. It sometimes happens that the roof of Kupffer's vesicle is not vaulted, but forms a sharply indented arch (Fig. 82). Whether the indentation seen in such individuals has any significance may be doubted.

VI. NEURAL CHORD; SURFACE ECTODERM; EYE.

Neural chord.—In the early stages the ectoderm over the entire embryonic shield is greatly thickened (Fig. 53, Pl. XCIV) in comparison with the non-embryonic ectoderm. This wide plate of thickened ectoderm has been called by Götte the "axenplatte." Along the middle line a thickening forms the well-known "keel," and as this grows deeper the lateral parts of the plate grow thinner (the cells being used up in forming the keel), until there is finally a narrow deep keel passing at the sides directly into thin ectoderm (Figs. 57 and 58, Pl. XCV). This diminution in width of the embryonic ectoderm and formation of a neural keel is associated with a general diminution in the width of the embryonic area, as may be seen in the surface views and on comparing Fig. 53 with Fig. 57. In the Bass, in the posterior region of the embryo, there is no neural furrow (Fig. 53, Pl. XCIV; Figs. 54 and 56, Pl. XCV). In the brain and anterior trunk regions, however, there is a well-marked furrow, into which the epidermic stratum sometimes dips (Fig. 58), or as often passes over like a bridge (Fig. 57), as has been remarked by Hoffmann (17). (Henneguy is entirely mistaken when he explains the separation of the epidermic stratum from the bottom of the furrow, observed by Hoffmann, by supposing that the cells just beneath the epidermis were badly preserved). The neural furrow is a transitory feature, disappearing a short time after the stage shown in Figs. 57 and 58, Pl. XCV.

As to the manner in which the keel is formed, Götte's description (16) covers the ground pretty thoroughly. The lateral parts of the axenplatte, or the "medullar platten," as Götte calls them, crowd toward the median line. Here the "Zellenmassen nach unten auswcichen, und die Axenplatte so gewissermassen in derselben Richtung eine geschlossene Falte schlägt, was auch durch die vergängliche, oberflächliche Furche angedeutet wird." (Götte, 16, quoted from Hoffmann, 17, p. 21.) In the Figs. 53, 54, 57, and 58 the direction of cell movement in the region of the keel is easily discerned from the cell outlines, and is indicated by the arrows. Cell multiplication appears to play no part in forming the keel, which is produced from a mass of preformed material by "Zellenverschiebung." As may be gathered from the quotation, Götte believes that the "Zellenverschiebung," by which the keel (which equals a "geschlossene Falte") is built up, represents the invagination by which in most vertebrates the medullary groove is produced. I fully agree with him in this view of the process. The peculiarity of the Teleost in this respect may perhaps be expressed as follows: In the Teleost the cells which are destined to form the medullary cord are precociously developed in the requisite numbers (axenplatte). When the time comes to form the cord, the preformed cells move into their destined places, following in the main lines of movement (see arrows in Figs. 53, 54, 57) which, in the ancestor indicated the path along which the floor of the medullary groove traveled in the course of its deepening. In the ancestor, these lines of movement (see Fig. 6, arrows *b*) were (accepting for the moment the view of His and Hertwig) the resultants of the combined forces produced by cell multiplication taking place in direction of arrows *a*. In the Teleost, the causal connection between cell multiplication and direction of movement is not present, but the direction of movement itself has been retained.

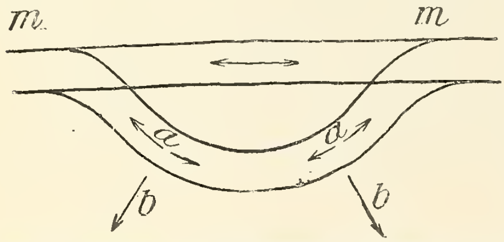


FIG. 6.—Diagram to illustrate formation of invaginate groove, as it is supposed to take place according to the "principle of unequal growth."

It is impossible here not to be tempted into carrying the comparison a little further, in the hope of getting some light thrown on the underlying principle of certain embryonic processes. One of the apparently simplest of such processes is seen when a unicellular membrane develops, by the method of invagination, a pit or a groove—as, for instance, in the development of an invaginate gastrula, or in the formation of an ideally simple neural groove. This phenomenon has received a well-known explanation, the strongest exponents of which are His and Hertwig. The principle involved in this explanation scarcely needs a description after Hertwig's name for it has been given. It is called by Hertwig (Lehrbuch, p. 58) "das Princip des ungleichen Wachsthums," and is briefly this: Suppose the membrane in the diagram (Fig. 6) to be composed of a single layer of cells. Now let rapid cell multiplication at right angles to the surface be set up over the area included between *m* and *m*. Pressure is exerted in the direction of the arrows, *a*, but meeting the lateral parts of the membrane which are not suffering cell multiplication, and hence act as rigid barriers, the effect of the pressure is first to form a groove, and then as the number of cells, and consequently the extent of surface, continues to increase, to drive the groove in the direction of arrows *b*. The mechanical simplicity of the explanation readily explains its popularity, and if true, its importance can scarcely

be overrated, for it would then give us a clear insight into that most interesting problem: what is the mechanism by which heredity works in the ontogenetic formation of organs? Accepting the explanation, the formation of a groove could be conceived of as taking place, because a certain hypertrophic stimulus had been applied to a long narrow area of the membrane. To give the stimulus was the duty of heredity, but after that heredity had no need to concern itself, for the mechanical pressure set up by the growth of the cells effected the rest.

In analyzing the "principle of unequal growth," we must give as great a precision as possible to the facts of the case. What we really see is (1) that cell multiplication takes place over the area *m* to *m*, and (2) that the area invaginates to form a groove. While it is possible that the second fact may be the mechanical necessity of of the first, it is also possible there may be no causal connection between the two. In such a problem as this, in which experimentation is out of the question, our only hope of a solution lies in a comparison of several cases where the result is the same, but where the two factors bear different relations to each other. Now, in the Teleost the factors, which in the invaginate ancestor were supposed to be causally connected, are wide apart in time. The cell multiplication takes place very early, and long after that is over the cells begin to move along lines, in general identical with those which in the ancestor marked out their path of progression. It would thus seem probable that in this case (that of the Teleost) heredity deals directly with the individual cells, though by what means a cell is induced to travel from the periphery of the axenplatte towards the axis, and is then sent out along the old lines, is assuredly beyond our present comprehension.

Returning to the ancestral type, it is clear there is not only no necessity of applying the "principle of unequal growth," but the probability is that the same relation between heredity and the individual cells which was deduced in the case of the Teleost exists here also; and that, as the new cells are brought into existence by fission, they stick together and move along their paths not because of a mechanical pressure but in obedience to what for want of a better term might be called the instinct of heredity. To sum up the case: When an area invaginates we get the impression that it does so because pressure is applied in a particular way. But the impression is due to the facts (1) that the cells migrate altogether and (2) that cell migration and fission take place coincidently. And this view of the case is borne out by the observation that cells follow the ancestral lines of migration when they are clearly not under the influence of a common pressure.

In this connection the peculiar modification of the folding process by which the alimentary canal of the teleost is produced, deserves a word. The manner in which the cells slip one under the other to take their place in the wall of the canal suggests strongly the comparative independence of the individual cells, and yet the result is the same as if a membrane had folded in the ordinary way.

Returning to the actual development of the neural cord, it is difficult to assign the proper significance to the neural furrow, *n.f.* It is clearly not homologous in the ordinary sense with the medullary groove of other vertebrates, for it disappears while the groove becomes the central canal. A careful examination of the surrounding cells (Fig. 57, Pl. XCV) leads to the conclusion that the furrow owes its existence to the fact that these cells share in the general movement indicated by the arrows. This movement we have seen represents the ancestral invagination, and thus, though the

furrow can not be said to be homologous with the medullary groove, the causes which produce the two grooves are the same. This consideration shows us, I think, that it is permissible to regard the furrow as representing the extreme upper part of the medullary groove, the chief part of which is ideally present in the middle line of the keel.

Minot has recently in a brief communication to the American Naturalist (November, 1889) urged that no good reason exists for believing the solid keel of Teleostei to be a derived structure. He regards the keel as representing an ancestral nerve cord, which arose as a thickening of the ectoderm, and hence as directly akin to the nerve cord of annelids. The formation of a canal within the keel is, for Minot, the primitive method. The open medullary groove is a secondary feature. This view does not, I think, find support in the ontogeny of the teleostean nerve cord, for all the details here point to the derivation of the keel from an open groove.

Like Götte and subsequent investigators I have not found anything which could confirm Calberla's account of the development of the keel in *Syngnathus* (10). In the Bass there is no special sheet of cells running down from the neural furrow into the keel mass.

The strange interpretation which Kupffer (26) has applied to the neural furrow in the Trout, regarding it as a primitive groove homologous with that of Amniota, has been sufficiently criticised by Henneguy (18, p. 531). The account which Miss Johnson (23) has given of a fusion of layers in the Newt, along the median dorsal line, does not find support in the Teleost, and its presence in the Newt must, I think, still be regarded as problematical.

Further development of the keel.—In the series of transverse sections (Figs. 60–64, Pls. XCV and XCVI) it is seen that the wide medullary plate disappears last in the posterior region. The neurenteric streak need not detain us. It is composed of the fused neural cord, notochord, and hypoblast. The notochordal cells are sometimes distinguishable from the rest (Fig. 66). The constriction of the keel from the surface ectoderm has begun in the neck region (Fig. 62). Fig. 63, through the brain behind the eyes, and Fig. 64, through the eyes themselves, call for no explanation. The constriction of the entire neural cord from the ectoderm is finished by the time the embryo is 45 hours old (Figs. 88 and 90, Pl. XCVIII, and Fig. 94, Pl. XCIX, through the trunk, and Figs. 95, 96, and 97, Pl. XCIX, through the head).

The formation of the central canal, cavities of the brain, and optic sacs, is accomplished in the manner described by Henneguy (18) by the simple separation along the middle line of the constituent cells. Oellacher (33) and Hoffman (17) state that the central cells disintegrate, and that thus the cavities are established. This is not so in the Bass.

In the stage when the optic sacs begin to form (Figs. 62, 63, and 64) the cells composing the brain and spinal cord are elongated at right angles to the median plane of the embryo, but they are interlocked and disposed in an irregular fashion. The beginning of this arrangement may be seen in Fig. 57, Pl. XCV. The cells thus arranged begin, as seen in transverse section, to dispose themselves in two rows (Fig. 72, Pl. XCVII) which, at first interlocked at their inner ends, gradually acquire a more even dividing surface (Figs. 75 and 78, Pl. XCVII). The process continues until the inner ends of the cells form an approximate plane (Fig. 97, Pl. XCIX). The separation of the opposing surfaces takes place first, at least in the spinal cord, at the upper and lower edges of the canal (Fig. 90, Pl. XCVIII, Fig. 94, Pl. XCIX). The characteristic shape of the

embryonic *canalis centralis* is then acquired (Fig. 102, Pl. C; Fig. 127, Pl. CIII). When the central canal is first established I am disposed to think the wall of the canal is everywhere but one cell thick (Fig. 90, Pl. XCVIII). It is difficult, though, to make sure of this in sections (see Fig. 94, Pl. XCIX). After the canal is once established the wall increases in thickness (Fig. 110, Pl. CI), but even at the time of hatching the posterior end of the cord has a unicellular wall (Figs. 119 and 126, Pl. CII). Likewise in the brain when the cavity is first established, the wall is but one or at most two cells thick (Figs. 95, 96, and 97, Pl. XCIX).

General development of the embryonic brain.—At the time of hatching, the brain is not only histologically undifferentiated but is morphologically exceedingly simple. From the surface views alone (Figs. 146–150, Pls. CVI and CVII) almost the whole development may be gathered. The cerebral vesicles of the higher vertebrates, which make their appearance in the Trout, are not developed in the Bass; at least I have never found a stage in which they were present. In Fig. 146, Pl. CVI, the optic sacs and that part of the brain with which they communicate have been hollowed out. Elsewhere the neural cord is solid. In Fig. 147, Pl. CVI, the central canal and its cerebral continuation are established, and there is a constriction (*m. con.*) marking off the anterior from the posterior part of the brain. The swollen portion of the brain directly in front of the constriction develops into the mid-brain while the portion behind the constriction becomes the medulla. It will be seen that at first the medulla is narrower than the mid-brain. In Fig. 148 the fourth ventricle is developed (section given in Fig. 96, Pl. XCIX), and in connection with the appearance of this cavity, aided also by the increase in thickness of its own walls, the medulla has become much wider than in preceding stages, and considerably exceeds the mid brain in width. A longitudinal section of this stage is given in Fig. 83, Pl. XCVIII. Figs. 149 and 150, Pl. CVII, are views of the brain from below and above, respectively, not long before hatching. The stage drawn in Fig. 150 is somewhat the older, but the difference scarcely concerns the brain. The constriction between the medulla and mid-brain is a deep one, but the increase in width of these two parts of the brain involves especially the dorsal surface, as may be seen on comparing the two surface views, or in the sections Figs. 131–133, Pl. CIV, and consequently both the eye and the ear are overarched by the medulla. Two folds, the subsequent history of which I have not followed out but which would seem to form the cerebellum, appear in this stage (*cer. f.*, Fig. 150). The optic nerves come off from the ventral surface of the brain and run into the anterior parts of the optic cups. The part of the forebrain in front of the optic nerves which will develop into the hemispheres is small and undifferentiated.

An examination of a series of transverse sections through the brain at the time of hatching will supplement this description of the embryonic brain. Figs. 128–131, Pl. CIII and CIV, are successive sections from behind forwards through the medulla. The increase in thickness of the walls and general change of shape in comparison with earlier stages is seen on referring to Fig. 96, Pl. XCIX. Fig. 123, Pl. CII, is through the cerebellar (?) folds (*cer. f.*). Fig. 133, Pl. CIV, is just in front of the cerebellar folds; the thin roof of the fourth ventricle here would seem to correspond to the valve of Vieussens. Fig. 134, Pl. CIV, is through the mid-brain and shows the iter and developing optic lobes. The infundibulum (*Inf.*) in its course backwards is met with in this section. Fig. 124 is a little in front of the last section, and from a slightly younger stage. The part of the brain here met with is the third ventricle, as

is shown by the presence of the infundibulum. The latter in this stage has barely begun to grow backwards. Its composition of long columnar cells needs no description. Fig. 135, Pl. CIV, is through the anterior part of the eyes. The third ventricle here sends up a dorsal process, presumably towards what will become the pineal gland. Ventrally the optic nerves (*op. n.*) are met with. The most peculiar feature in the embryonic brain is clearly the great forward extension (Fig. 134) of the thin roof, characteristic of the fourth ventricle. The condition of the spinal cord at the time of hatching is sufficiently indicated in the Figs. 119 and 126, Pl. CII, Fig. 127, Pl. CIII, representing transverse sections from the extreme posterior end forwards.

The histological differentiation into nerve cells and fibers begins both in the spinal cord and brain shortly (about 12 hours) after hatching. A peripheral accumulation of fibrous matter is formed, and some of the peripheral cells abandon their simple elongated embryonic shape, and assume the appearance of rounded nerve cells, having in general a single process (Fig. 136, Pl. CIV, spinal cord). The transformation of the elongated embryonic cells into rounded nerve elements proceeds rapidly, and on the second day after hatching there are no embryonic cells to be seen (Fig. 139, Plate CV, larva of 112 hours). During the histological transformation of the cells the canal of the spinal cord also loses its embryonic shape. The successive stages in the metamorphosis of the canal are shown in Fig. 136, Pl. CIV, and Figs. 139, 141, and 143, Pl. CV. The closure progresses gradually from the edges towards the center. The distribution of the fibrous matter on the fourth day after hatching (larva 160 hours) is shown in Fig. 143, Pl. CV. It is only on the third or fourth day after hatching that the spinal nerve roots can be made out (Figs. 141 and 143, *d. n. r.*, *v. n. r.*), and then they are so very small that their presence alone can be demonstrated. So with most of the cranial nerves, their minute size renders it impossible to follow their development.

Histological differentiation of the surface ectoderm.—The thin membranous ectoderm of the non-embryonic area has already been mentioned. It is composed of the epidermic stratum, and one or two strata of flattened cells. At the end of embryonic life, when the yolk sac begins to disappear, the ectoderm covering it gradually becomes thickened while the rest of the ectoderm grows thin (Figs. 139–141, Pl. CV). It is thus brought about that the yolk ectoderm in the larval stages is thicker than the rest of the layer.

After the wide neural plate (axenplatte) has been transformed into a deep keel, the ectoderm of the embryo, except in the immediate neighborhood of sense organs, is made up of the epidermic stratum and two strata of "nervous layer" cells. Its condition just before the separation of the neural cord is shown in Fig. 81, Pl. XCVII, part of a section, such as Fig. 75, Pl. XCVII. The further development of the general ectoderm during embryonic life consists in the vacuolation of the outer stratum of the nervous layer (1, Fig. 81), and the flattening of the inner stratum (2, Fig. 81). The vacuolation has begun in Fig. 81. Almost all of the cells of the outer layer become vacuolated, and usually there is in each cell a single large vacuole, as is shown in Fig. 112, Pl. CI, a more highly magnified view of the ventral portion of a section such as Fig. 111. Inside the vacuolated layer is the second stratum made up now of flattened cells. This condition of the ectoderm is indicated in the figures of the later embryonic stages, such as Fig. 126, Pl. CII.

The continuous dorso-ventral fin of the larva is indicated at a comparatively early stage in embryonic life by a groove in the nervous layer of the ectoderm (*f. gr.*, Figs. 88, Pl. XCVIII; 99, Pl. XCIX). The groove first appears just before the tail begins to fold off, at the posterior end of the body and on the dorsal side (Fig. 88, *f. gr.*). As the tail is folded off the groove extends round its tip to the ventral side (Figs. 99, 100, Pl. XCIX), and as the folding off of the tail continues, the formation of the groove progresses in an anterior direction on both dorsal and ventral surfaces. In the Bass, as in other Teleosts, after the tail has grown out a short distance it becomes laterally compressed, the dorso-ventral fin fold (*d. f.*, *v. f.*, Figs. 111, 112, Pl. CI; 119, Pl. CII) developing at the same time. By this means the tail end of the embryo is made to lie against the yolk on its side. From the start the cells which line the fin groove (*f. gr.*, Figs. 88, 99), and which belong to the second stratum of the nervous layer, are larger and not so flattened as the surrounding cells. When the fin fold begins to develop (Fig. 112) the groove extends into it, the cells of the second nervous stratum retaining an approximately cubical shape. The cavity of the fin fold (Fig. 112) disappears before the close of embryonic life, but the double sheet of nonvacuolated cells persists.

Eye.—The development of the eye does not differ from the generally accepted account for the Teleosts, except in regard to the lens, and it may therefore be run over very briefly. The solid optic sacs (Fig. 64, Pl. XCVI) are separated from the brain by a fissure which extends from above downwards and, as in other Teleosts, from behind forwards, and hence the position of the optic nerves in later stages (Figs. 135, Pl. CIV, and 149, Pl. CVII). The cavity of the optic sac is established in the way already described for the neural cord, and the wall of the sac is at first made up of a single layer of cells (compare Fig. 72, Pl. XCVII, through the still solid optic sac, with Fig. 80, Pl. XCVII, after the cavity is formed). In the folding of the optic sac to form the optic cup there is nothing which calls for special attention. The inner layer of the cup thickens and forms the retina, the outer layer becomes transformed into the ordinary stratum of flat cells (pigmented epithelium of the choroid, Figs. 80, Pl. XCVII, 97, Pl. XCIX, 108, Pl. C). The choroidal fissure is still present at the time of hatching (Fig. 151, Pl. CVII).

The development of the lens in the Bass affords an interesting illustration of how one modification in the embryo leads to another. In the trout the head region of the embryo is early lifted up above the yolk, so that it is possible for the lens to develop, as it does in the ordinary position. It is developed as a solid thickening in which the epidermic stratum takes no part (Henneguy). In the Bass, however, the whole embryo, head as well as trunk, is buried in the yolk (Fig. 97, Pl. XCIX), and it is only late in embryonic life, long after the lens has formed, that the head begins to be folded off (Figs. 130, Pl. CIII, and 135, Pl. CIV). On glancing at Figs. 72, Pl. XCVII, 80, Pl. XCVII, and 97, Pl. XCIX, it is seen that it is impossible, because of the reason just mentioned, for the lens to develop on the side of the head, as in other vertebrates—the layer here consisting of periblast (*p*) and not ectoderm.

The lens makes its first appearance while the optic sacs are still solid, as a thickening of the nervous layer of the ectoderm. Its position is on the dorsal surface in the angle between the ectoderm and periblast (*ln.* Fig. 72, Pl. XCVII). The thickening becomes transformed into an open invagination which grows down between the optic cup and the periblast (*ln.*, Fig. 80, Pl. XCVII). The inner wall of the invagination is made up of columnar cells (*c. ep.*), and is therefore conspicuous, but the outer wall is

composed of small flattened cells and is apt to escape observation, especially as its continuity is often broken. In stages subsequent to that shown in Fig. 80 the outer wall is not found (Fig. 97, Pl. XCIX), the lens being derived exclusively from the inner wall of the columnar cells. When the optic cup begins to form, the layer of the columnar cells (*c. ep.*) also suffers invagination, and the concavity thus established begins to be filled with cells (*ln.*, Fig. 97, on right side).

In this condition the connection of the layer of columnar lens cells with the surface ectoderm is maintained by a few flattened and rather irregularly shaped cells. The connection is, however, broken (left side of Fig. 97) before the lens becomes transformed into a solid mass, which is brought about by the increasing accumulation of cells in the above-mentioned concavity. After the invagination of the original columnar layer and the subsequent cell proliferation have converted the lens into a solid spherical mass, the superficial cells take on a columnar shape, while the inner cells become irregularly polygonal (Fig. 108, Pl. C). The further development of the lens was not traced with any exactness, though its condition some 15 hours before hatching is shown in Fig. 118, Pl. CII, where the distinction between the lens epithelium (*l. ep.*) and the lens fibers (*l. f.*) is obvious. The late development has probably nothing of especial interest, but the early development is a clear case of adaptation to the great delay in the folding off of the head.

VII. EAR; BRANCHIAL SENSE ORGAN; LATERAL LINE.

It has been noticed in the trout that the anlage, which was supposed to develop into the ear, is remarkably long (Oellacher). I have found that this anlage not only gives rise to the ear but to a functional branchial sense organ and to the organs of the lateral line as well. Before the blastopore closes there is found behind the eye a long shallow furrow (the sensory furrow, Fig. 62, Pl. XCV, *s. f.*) in the nervous layer of the ectoderm, the epidermic stratum sometimes passing over as a bridge, and sometimes filling the concavity with a few more or less detached cells. The transverse section (Fig. 62) shows that the groove is lined by nearly columnar cells. By the time the blastopore closes, the furrow is more marked, and presents in surface view the appearance shown in Fig. 146, Pl. CVI. The nervous and epidermic layers are henceforth distinctly separated, the latter always bridging over the groove. Partly owing to the convexity of the dorsal surface of the embryo, and partly to the greater thickness of its proximal than its distal wall (see Figs. 68–71, Pls. XCVI and XCVII), the sensory furrow has, when viewed from above, the aspect shown in Figs. 146 and 147, Pl. CVI; it is only the proximal wall that is obvious. At two points the furrow begins to deepen (Fig. 146, *a. s.*, and *B. s. o.*), the deepening taking place downwards and inwards. At these two points the auditory sac and the branchial sense organ will respectively be formed. Anteriorly and posteriorly the furrow with its thickened wall dies away in the general ectoderm. Its extent from behind the eyes nearly to the somites is indicated in the figure.

In Fig. 147, Pl. CVI, a further stage in the development of the sensory furrow is shown. The deepening of the furrow in the auditory and branchial sense organ regions has continued until there are now two well-marked sacs, the anterior of which is the branchial sense organ (*b. s. o.*), the posterior the auditory sac (*a. s.*). Between

the two sacs persists the connecting portion of the sensory furrow, and behind the auditory sacs the furrow is continued for some distance. The posterior portion (*l. l.*) of the furrow constitutes the anlage of the lateral line.

In the next stage (Fig. 148, Pl. CVI) the sensory furrow has definitely separated into its three derivatives. The auditory sac has closed, and with this closure was naturally brought about the division of the furrow. The three derivatives at this stage have not yet begun to move away from each other. In a subsequent stage (Fig. 149, Pl. CVII) they are, however, wide apart. In this stage the gill slit (*g. s.*) has broken through, and just in front of it is the branchial sense organ. The auditory sac is already overgrown (see dorsal view) by the medulla, and the anlage of the lateral line (*l. l.*) has moved some distance backwards from its original position in front of the somites. In a still later stage (Fig. 150) the lateral line anlage has grown still farther back, and is incompletely divided into three "sense organs of the lateral line."

After this brief survey we may return for a more detailed description of these parts. The series of transverse sections (Figs. 68–71, Pls. XCVI and XCVII, numbered from behind forwards) is from a stage slightly less advanced than Fig. 147, Pl. CVI. The anterior section (Fig. 71) is through that portion of the furrow which has already begun to differentiate itself into the branchial sense organ (*b. s. o.*). The greater thickness of the proximal wall of the groove, and the cavity of invagination need no description. In going backwards from this section an unbroken though comparatively shallow furrow leads to the auditory sac (Fig. 70). Here the invagination has a greater width and depth than at any other spot. In passing towards the posterior limit of the auditory sac the invagination draws away from the brain (Figs. 68 and 69), as is indicated in the surface view, Fig. 147. In Fig. 70, through the middle of the ear sac, where the invagination is nearest the brain, it is impossible to speak of an auditory nerve, for here there is direct continuity between the brain cells and the lining cells of the invagination. The auditory nerve becomes recognizable as a proliferation of cells only where the sac is separated from the brain by some of the surface ectoderm (Fig. 69, *a. n.*). Behind Fig. 68 the invagination becomes shallower and narrower, constituting the anlage of the lateral line.

Figs. 78 and 79, Pl. XCVII, are from a stage intermediate between Figs. 147 and 148, but in which the auditory sac had closed. Fig. 79 is through the branchial sense organ (*b. s. o.*), which is deeper and of a more compact shape than in early stages. Fig. 78 is through the posterior part of the closed auditory sac (*a. s.*) and the anterior part of the lateral line (*l. l.*). As the section indicates, though the sensory furrow has broken up into its several parts, these parts still closely adjoin one another.

Now that the history of the sensory furrow has been carried to this point, it will be more convenient to treat each derivative separately.

Ear.—The ear, after its constriction from the surface and the rest of the sensory furrow, forms a closed sac, the wall of which is made up of columnar cells (Fig. 95, Pl. XCIX). One side of the sac applies itself pretty closely to the medulla, and during later stages the cells of this wall become greatly flattened. Two stages are given in Figs. 114, Pl. CI, 130, Pl. CIII, the latter showing the condition of the ear at the time of hatching. At this time the columnar sensory elements are restricted to a rather closely circumscribed area. The overarching of the ear by the medulla has already been mentioned.

Branchial sense organ.—After its separation from the ear the branchial sense organ has the character of a sac, one wall of which is much thicker than the other, and over the cavity of which passes the epidermic stratum. Its appearance in surface view is given in Fig. 148, *B. s. o.*, and a transverse section through a corresponding stage in Fig. 96, Pl. XCIX. Anteriorly and posteriorly, as may be seen in the surface view, the sac is not sharply delimited. The further development of the organ consists in the loss of its cavity, in histological differentiation, and in the transformation of its ill-defined anterior extremity into two cellular cords which doubtless serve as a source for the production of new organs.

On comparing Fig. 96, Pl. XCIX, with a slightly older stage, Fig. 106, Pl. C, it is plain that the cavity of the sac has grown shallower, and with this change the epidermic stratum has dipped into the cavity, which it now lines (Fig. 106). The effacement of the cavity, begun in this way, is continued until the originally conspicuous cavity is reduced to an extremely shallow indentation (Fig. 115, Pl. CI), and at the time of hatching (Fig. 131, Pl. CIV, *B. s. o.*) even this indentation seems to have disappeared.

Coincidently with the loss of its cavity the sense organ changes its shape, as may be seen by glancing through the sections, Figs. 96, Pl. XCIX, 106, Pl. C, 115, Pl. CI, 131, Pl. CIV, and the surface views, Figs. 148, 149 and 150. Whereas in the earlier stages it is a vaguely delimited sac, in the later stages it is a sharply defined superficial sense patch, of an oval shape, from which there runs forward a short sensory cord, *a. s. t.*, Figs. 149 and 150. Histological modification accompanies the change of shape. In Figs. 96 and 106 the cells are embryonic columnar cells, but in Figs. 115 and 131 the organ is largely composed of peculiar sense cells, the nuclei of which are basal. Some of these cells terminate in short stiff hairs which project from the surface. No macerations were made, and I am consequently not able to go any farther into details of the histology, which appears to be identical with that of the sense organs of the lateral line. It is plain that the organ is functional during the later stages of embryonic and during larval life. Its position directly in front of the embryonic gill slit is shown in the surface views.

When the sense organ assumes its definite shape, there is left in front of it a narrow tract of columnar cells in perfect continuity with the sense organ and obviously derived from the anterior part of the anlage shown in Fig. 148. This tract of cells is conspicuous in surface views of some stages (Fig. 149, *a. s. t.*), but towards the time of hatching it becomes difficult to see in such views, though sections show that it not only persists but continues to develop. The entire anterior extension of the sense organ may be spoken of as the forward sensory tract. This tract differentiates into two tracts, one of which runs directly forwards (anterior sensory tract) while the other runs somewhat dorsally (dorso-lateral tract).

Figs. 106 and 107, Pl. C, belong to the same series of sections and are from a stage intermediate between Figs. 148 and 149. Fig. 107 is through the anterior part of the forward sensory tract where it differentiates into the anterior tract (*a. s. t.*) and dorso-lateral tract (*d. l. s. t.*). Figs. 115 and 116, Pl. CI, are from another series and belong to a stage about like Fig. 149. Fig. 116 shows the connection of the two sensory tracts at the anterior end of the whole forward extension. Near the time of hatching the dorso-lateral tract extends a short distance in front of the anterior tract, occupying the position shown in Fig. 123, Pl. CII, *d. l. s. t.* During larval

life one or two sense organs are found in this region, and it is extremely probable that they arise from the dorso-lateral tract. Indeed this is made nearly certain by the condition of the anterior end of the tract at the time of hatching (Fig. 132, Pl. CIV). It is here larger than elsewhere, and the cells begin to assume the appearance of sense cells, as if a sense organ were going to form *in situ* as a modification of a particular part of the cord. This calls to mind Allis's paper on the lateral line of *Amia* (2), in which he describes sense organs originating at various spots along a growing cord by local cell proliferation. The significance of this method of multiplication of sense organs will be discussed after the formation of the lateral line has been described.

The anterior sensory tract is at the time of hatching very short, and just what becomes of it I do not know. Nor do I know whether the gill slits, which are subsequently formed, have branchial sense organs. If they have, the organs must be extremely inconspicuous compared with the single embryonic organ.

I think Hoffmann must have seen the branchial sense organ in the embryo of the trout, for on page 7 (17, 1883) he gives a wood cut (surface view) in which the organ is shown fairly well, though he calls it an embryonic "Spritzloch." Hoffmann must surely be wrong in his statement that there is an embryonic spiracle in the teleost. What he figures as such in his sections is the embryonic gill slit, which does not disappear at all, as he states is the case.

Lateral line.—As has been said, it is the posterior end of the common sensory furrow which is transformed into the anlage of the lateral line. In Fig. 147 the general character of this end is indicated. The furrow is here long, narrow, and (compared with the auditory invagination) shallow. Becoming independent on the closure of the auditory sac, the lateral line anlage forms an elongated narrow sac, the opening of which is bridged over by the epidermic stratum. Its appearance and position, just behind the ear, is shown in Fig. 148, *l. l.* A section through the anterior end of the lateral line at this stage is given in Fig. 78, Pl. XCVII, *l. l.*

Once independent of the rest of the furrow, the cavity of the lateral line invagination begins to deepen, becoming at the same time narrrower, while the lining cells grow more columnar. Fig. 105, Pl. C, represents a section through a stage four hours older than Fig. 148 and shows these changes in the character of the lateral line. The cavity is sometimes a simple narrow slit as in the "line" on the right side, and sometimes it is dilated at the bottom as on the left. At the ends of the lateral line the cavity is considerably wider, especially in its upper portion where the lining cells become continuous with the surface ectoderm, than in the middle; on the left side of Fig. 105 the section cuts the anterior end of the line. When the section is unbroken the continuity of the lateral line cells with the nervous layer of surface ectoderm is perfect, as in the figures. But sometimes the "line" parts from the ectoderm and appears in sections as, at first sight, a closed tube lying on the mesoderm. Examination, however, always shows the incompleteness of the apparent tube. The attachment to the ectoderm is stronger at the ends than elsewhere, and occasionally the "line" will separate from the ectoderm along its length, remaining attached at one or both ends. I have mentioned these imperfect sections because it was probably such that led Brook (4) to the conclusion that the Wolffian duct splits off from the ectoderm in the Teleosts. As will be seen later, I agree with the majority of investigators

in deriving the Wolffian duct from the coelom. What Brook mistook for the duct was very probably the lateral line anlage.

While the anlage remains an undivided sac the surface view, Fig. 149, and the section, Fig. 105, fairly represent its character. During its existence as a simple sac it increases in length considerably and at the same time travels from its early position in front of the somites to a position some little distance behind the first or second somite (compare Figs. 149 and 150). As to the manner in which the sac travels backward, I can only say that it does not plow its way through the surrounding passive ectoderm, as Beard (5) states is the case with the lateral line anlage of Selachians. Its continuity with the surrounding ectoderm prohibits this idea.

The formation of the separate sense organs begins some 10 or 15 hours before hatching. The elongated sac suffers a constriction and gradually becomes divided into two parts, which are at first connected by a strand of cells. During the constriction the backward growth of the whole anlage continues, so that the final position of the first (anterior) lateral line organ is some distance behind the first somite (Fig. 150, *l. l. o*[1]). Of the two parts into which the sac is divided, the anterior is the smaller and becomes the first (anterior) lateral line organ. The posterior portion by continued division gives rise to the remaining organs.

By the time the sac is divided into two distinct parts (Fig. 150, right side) a general change in the character of these parts, as contrasted with the early condition of the organ, is perceptible. The change especially affects the anterior part, as may be seen on comparing Fig. 113, Pl. CI, with Fig. 105. Fig. 113 is through the anterior half of the parent sac, which is connected with the posterior half by a short strand of cells. In the figure it is seen that the wide mouth of the parent sac no longer exists, and the connection of the sense-organ cells with the surface ectoderm is also of a different character The sense organ appears to have been constricted off from the general ectoderm, and in consequence the nervous layer as well as the epidermic stratum now passes over the mouth of the cavity. The cavity has also changed its character. It is much shallower and (compare Fig. 150, *l. l. o*[1].) is indeed almost spherical. It continues to grow shallower (Fig. 120, Pl. CII, *l. l. o*[1].) until it finally disappears (Fig. 127, Pl. CIII) or perhaps is represented by the slight superficial concavity which the sense organs of the lateral line possess at the time of hatching. During the later stages of its existence the cavity is so sharply outlined (Fig. 120, Pl. CII) as almost to suggest the presence of a cuticle. I have no stages in the development of the sense organ between that shown in Fig. 120 and the condition in Fig 127, but the path followed is probably the same as that pursued by the branchial sense organ: as the cavity of the organ continues to flatten out, the surface ectoderm dips into and lines it; only in this case the nervous layer must be pressed aside, for in the perfect organ (Fig. 127, Pl. CI) the sense cells are covered by the epidermic stratum alone. The histology of the sense organs of the lateral line is quite like that of the branchial sense organ already described.

The constriction by which the first lateral line organ is separated from the surface ectoderm affects all the rest of the original anlage. Both the connecting strand of sense cells and the posterior portion of the original sac are separated from the epidermic stratum by the nervous layer. Figs. 122 and 121, Pl. CII, are sections through different stages in the formation of the connecting strand (*con. st.*). In Fig. 122 the arrangement of the cells indicates the former presence of a cavity and suggests its

gradual obliteration by the elongation of the connecting strand. Fig. 121 shows the character of the strand commonly met with, in which the cells have no especial arrangement. The connecting strand continues to elongate, because of the backward growth of the posterior portion of the original anlage, until it becomes excessively thin and finally disappears. At the time of hatching I am unable to find any trace of it. However, my inability to trace the origin of nerves in the Bass shows that the apparent disappearance of the strand is not a conclusive argument against the supposition (Beard, 6) that it may persist as a fine nerve thread.

The posterior of the two parts into which the first constriction separates the original anlage is, as I have said, the larger of the two. In transverse section it presents about the same appearance as the anterior organ in Fig. 113, Pl. CI. Its cavity is, however, a much elongated one (Fig. 150, right side). This portion of the primitive sac suffers a constriction which begins before the first connecting strand has disappeared (Fig. 150, left side). Of the two parts into which it is separated the anterior (*l. l.* o^2., Fig. 150, left) becomes the second lateral line organ. The condition of this organ at the time of constriction is fairly represented by Fig. 120, Pl. CII. Its cavity subsequently disappears, and at the time of hatching it is a histologically differentiated organ (*l. l.* o^2., Fig. 126, Pl. CII), lying just in front of the anus.

The posterior part of the original anlage, which the second constriction pinches off (Fig. 150, left), presents at first about the same appearance in section as the organ shown in Fig. 120, Pl. CII. It lies in front of the anus. At the time of hatching, some 10 hours after the constriction begins, this portion of the lateral line anlage forms a rod of cells lying behind the anus, on which sometimes one, sometimes two, sense organs are found in process of forming. The rod lies like the sense organs in front of it, along the middle line of the lateral surface, and I could not distinguish it in surface preparations. The series of sections, 126^{i}–126^{iv}, Pl. CIII, however, satisfactorily elucidates its nature. Each section represents the lateral line region of the opposite sides. Glancing through the series it will be seen that the rods do not lie exactly opposite each other, and that moreover on one side two sense organs are indicated, on the other but one. The section 126^{i} is the most anterior of the series and shows that on the left side the rod does not extend so far in front, while on the right there is a sense cord (*s. c.*) which, however, extends but a short distance in front of the sense organ (*l. l.* o_3, 126^{ii}) and must be regarded as the anterior end of that organ. Fig. 126^{ii} lies four sections farther back. On the left there is no sense cord; on the right there is a sense organ (*l. l.* o_3.) in process of forming. It is in about the same stage as that of Fig. 120. Going backwards from Fig. 126^{ii} to 126^{iii} the sense organ on the right gradually passes into the connecting strand (*con. st.*); on the left a short rod of cells is first met with which proves to be the anterior end of the sense organ, *l. l.* $o_3{}^{i}$. Continuing back from 126^{iii} to 126^{iv} on the right, the connecting strand passes into another incipient sense organ, *l. l.* o_4., but on the left there is behind the organ, *l. l.* $o_3{}^{i}$., nothing but a simple cord of cells, which comes to an end not far behind 126^{iv}. The organ *l. l.* o_4. is likewise prolonged backwards as a short cord of cells. In no part of the postanal sense tract on either side has histological modification set in.

From the series of sections it is plain that the cord of cells on the right is suffering constriction and is thus giving rise to two organs, *l. l.* o_3. and *l. l.* o_4. On the left there is no constriction and but one organ is forming. The cavity in each of these

postanal organs is probably a remnant of the cavity of the original lateral line anlage, and the manner in which the organs are formed appears to be essentially like that pursued in the case of the anterior organs; but henceforth whatever new organs are formed must follow a different course of development, for the cavity of the original anlage has, so to speak, been used up, and the posterior part of the sense tract is now a simple cellular cord without any cavity at all. It would seem probable that this terminal sense cord continues to grow backwards, developing sense organs along its course by local proliferation. The probability rests on the presence of a terminal simple cord in the tail, on the existence of sense cords in the head, and on the formation of sense organs along such cords in *Amia* (2).

The lateral branch of the vagus, which innervates the lateral line organs and which is so evident in Selachian and (Hoffman, 21) Trout embryos, can not be distinguished in the Bass during embryonic life, nor could I make it out in larvæ of 2 or 3 days.

COMPARATIVE.

Common sensory anlage.—As far as I know, the formation of the ear, lateral line anlage, and branchial sense organs, by the division of a common anlage, has never been recorded before. I was consequently pleased to find a couple of figures in one of Kupffer's papers (26, 1884) which strongly suggest that the organs are formed in the same way in the Trout; Kupffer's figures, which are surface views (Taf. 11), show that at first there is on each side of the neck one sac, then two, and then three. The structures appear in the figures to be hollow, but Kupffer says they contain a central mass of loosely connected cells. Kupffer describes the structures as branchial arches and says the ear arises independently of them. Unfortunately no sections are figured in the paper, and it is therefore impossible to decide whether Kupffer is right in his interpretation or not. The general resemblance of the "schlundbogen" in his Fig. 14, Taf 11, to the series of sense organs in my Fig. 148 is certainly very marked.

The fact that there is in the Bass a common anlage for the ear, branchial sense organ, and lateral line has certainly no phylogenetic significance. It can only be regarded as a convenient method of forming these organs, which the embryos of certain animals have adopted. It however serves to emphasize in a striking way the serial homology between the organs which previous work has already made so probable.

Branchial sense organ.—The existence of a histologically differentiated sense organ, which bears such obvious relations to the gill slit as does that of the Bass, makes one wish that the fate of the so-called primitive branchial sense organs of Selachian embryos were better known. In spite, however, of our ignorance regarding the precise fate of these organs, it seems impossible to avoid the homology between what I have called in the Teleost a branchial sense organ and the patch of thickened ectoderm which Beard (5) describes above each gill slit in the Selachian. There also seems good reason for accepting Beard's belief that these "primitive branchial sense organs" indicate the position of a series of sense organs of very ancient origin. We are thus led up to the rather surprising conclusion that while in the Selachians the position of these ancient organs is only indicated by thickened patches of undifferentiated ectoderm, in the highly modified group of Teleostei one at least of the organs has been retained in a functional condition, though probably very different in structure from the ancestral organ.

Beard (*l. c.*) supposes that the sense organs, primitively situated one above each gill, gradually increased in number and spread over the head. The phylogenetic method of increase he thinks was probably division, and in this I agree with him, basing my belief chiefly on the development of the lateral line organs in the Bass. In actual ontogeny the method generally employed would seem to be the formation of a sensory cord which grows out from a primitive center and along which sense organs develop by local proliferation (2).

The serial homology of the nose, ear, and branchial sense organs, so strongly supported by Beard, receives new confirmation in the development of the Teleost, though the original sac-like character of the branchial sense organ (lateral line organs also) in the ontogeny of the Bass makes it, I think, necessary to alter the details of the comparison instituted by Beard between these organs. Beard believed, and it is generally so believed, that the primitive condition of the segmental sense organ of vertebrates was that of a superficial sense patch, something like the lateral line organs of larval fishes. In the auditory and olfactory regions the originally simple sense patch gave rise by division to a number of such organs, which were confined to a small area The whole area subsequently became invaginated to form respectively the auditory and olfactory organs, the sac-like structure of which is therefore highly secondary as compared with the superficial sense patch. Now, according to this view, it is difficult to account for the fact that the branchial sense organ and the (embryonic) organs of the lateral line originate in the Teleost as sacs, which subsequently flatten out into the well-known superficial sense organs. If the latter condition represents the primitive condition in the vertebrates, why need the organs go to the trouble of running through such a complicated metamorphosis? It is, of course, impossible to reach a decision in regard to this point when the known facts are so few, but for the present it must be borne in mind that there is at least a possibility that the sac-like condition of the organs in the embryo Bass represents a phylogenetic stage; and in view of this possibility, Beard's theory of the origin of auditory and nasal sacs from a collection of segmental sense patches can not be accepted, for there is at least as much to be said for the other theory, viz, that the ear and nasal sac represent single sense organs. According to the latter view the nasal sac (which arises in the Teleost as a simple invagination) has retained more closely than any of the other members of the series the structure of the ancestral segmental sense organ; the ear has been shut off from the surface and transformed into a closed vesicle, while the remaining organs have been flattened out into superficial sense patches.

Lateral line.—Beard has described the formation of the lateral line in the Salmon (6) as taking place in the following way: In the region of the neck just behind the ear a cord of cells is split off from the nervous layer of the ectoderm; the cord grows backwards along the whole length of the embryo; it then becomes thickened in each segment of the body, the intervening parts growing thin and finally passing out of sight, though the author thinks they may still persist as fine nerve strands. The thickened parts become the sense organs. The development of a sense bulb from one of the segmental thickenings takes place in the following manner: Certain of the cells which are next the outer surface lengthen until they reach the surface of the body, when they acquire terminal hairs; the remaining cells arrange themselves round the base of these cells as a center.

It will be seen that the chief points of difference between Beard's account and my own are two: (1) In the Bass the anlage of the lateral line is an elongated sac; in the Salmon it is said to be a cord of cells. (2) In the Bass the anlage divides into the separate sense organs during its growth backwards; in the Salmon there is first formed a continuous cord, and then special parts of it become thickened to form the sense organs, the intervening parts disappearing. The formation of a continuous cord may easily be looked on as a secondary modification of the method displayed in the Bass: the division into separate organs has merely been delayed until the anlage has grown all the way back.

Hoffmann's (21) account of the development of the lateral line is not so easily brought into harmony with my description. According to Hoffmann the lateral nerve develops some time before the sense organs. The former arises as a histologically modified cell string, which is at first a part of the nervous layer of the ectoderm. The string gradually moves out of the ectoderm, coming to lie at some distance internal to it, but at certain points connection is retained with the nervous stratum. The cells establishing this connection become the side twigs of the lateral nerve (each leading to a segmental sense organ). At the point of connection with the side twigs, the cells of the nervous layer become histologically modified and form a sense organ. Hoffmann points out the difference in the development of the two parts of the lateral line in the following words:

Zwischen den ersten Anlage des Ramus lat. nerv. Vagi und den der Sinneshügel besteht also nur dieser Unterschied, dass Erstgenannter in einem sehr frühen Entwicklungs-stadium auftritt und nicht segmentirt sich anlegt, während die Sinneshügel der Seitenorgane erst in einer viel späteren Periode der Entwicklung, zur Ausbildung kommen und *gleich vom Anfang an segmentirt sind.*

It seems impossible to reconcile Hoffmann's description with the development of the Bass. For in the latter the origin of all the lateral line organs from a single cervical sac is unmistakable, while according to Hoffmann they arise *in situ* by local modification of the ectoderm. The development of the Bass is so very clear in this respect that I do not think Hoffmann's account can be accepted without confirmation.

In the Selachians (Beard, *l. c.*) the lateral line anlage consists of a thickened stripe of ectoderm, made up of the "primitive branchial sense organs" of the last three or four gill slits. This anlage grows backward, plowing its way through the indifferent ectoderm and becoming transformed into the lateral nerve and the lateral line proper. The exact manner in which the lateral line itself develops has not been worked out very satisfactorily. In the main point, though, there is an agreement between the Selachians, Salmon (Beard, 6), and the Bass: the organs of the lateral line originate as an anlage confined to the cervical region. It is difficult to homologize precisely the lateral line anlage in the Bass and Selachian, for while in the latter the anlage is composed of the sense organs of the last four gill clefts, counting in the rudimentary cleft, in the former it lies behind the gill clefts and hence represents only those which have disappeared. It would thus seem that the anlage in the Teleost contains two less branchial sense organs than in the Selachian.

The agreement between the forms mentioned above, as to the origin of the lateral line anlage, is strong evidence that Beard's conception of the lateral line is the true one. The lateral line is, for Beard, comparable with a tract of head sense bulbs. The latter tract phylogenetically arose by the multiplication of a primitive branchial sense

organ, the multiplication taking place along a line which gradually extended farther and farther from its starting point. In the case of the lateral line the phylogenetic development has been the same; the sense organs of the last few gill slits instead of sending out tracts over the head proliferated in a backward direction along the middle line of the lateral surface of the body, and so gave rise to a row of organs stretching far beyond the region (branchial) to which they were originally confined. Balfour foreshadowed this theory when he suggested (T. B., vol. XI, p. 445) that the development of the anlage in the neck and the innervation of the line by the vagus indicated that "the lateral line was probably originally restricted to the anterior part of the body."

The homology instituted by Eisig (11) between the lateral line organs of fishes and the "Seiten organe" of certain annelids (*Capitellidæ*) is well known. Balfour in his text book declined to accept it, and though Beard favored the homology in his paper on the Teleostean lateral line (6), after studying the Selachians he gave it up. Now that the early development of the lateral line is approximately known in Teleosts and Selachians, there seems less than ever to be said for the homology. If it could be shown that the segmental sense organs of annelids, leeches, etc., arise from an anterior anlage, which grows back and, so to speak, distributes the sense organs along the trunk, the homology might well be supported. But, as far as I know, the invertebrate segmental sense organs arise *in situ*.

Professor Whitman, in a paper on the "Segmental Sense Organs of Leeches" (44), supported the homology in 1884, and has recently said (45) that he still regards the position as tenable, although aware of the difficulties. Professor Whitman's paper dealing with this point will be awaited with a good deal of interest. In the mean time one can not but think that the segmental arrangement of the lateral line organs in some fishes (Salmon) has been looked at too closely, for in Whitman's account of the leech segmental organs there is found the following passage: "The developmental history of these lateral organs in the fish, where they make their first appearance as *segmental papillæ in the strictest sense of the words*, can not at present be explained on a more satisfactory hypothesis" (*i. e.*, hypothesis of homology between leech organs and lateral line organs). But in the presence of so many fishes in which at the time of hatching there are only a few sense organs to the whole line (see Ryder, 34, p. 508), and in which there is consequently no segmental arrangement at all, it is obviously unwarranted to assume that fishes like the Salmon present the ancestral condition of the lateral line. Further, even if in the Salmon the lateral line organs do first make their appearance segmentally arranged, the Bass development and Beard's observations make it extremely probable that here also the lateral line anlage first forms in the neck and then grows back, producing a continuous long cord on which the organs subsequently develop, a method which it seems best to look on as a secondary modification of the simple increase by division, which the organs undergo in the embryo Bass.

VIII. ORGANS FORMED FROM THE MESODERM.

Cœlom.—The lateral mesoderm plates of the young embryo seen in transverse section in Fig. 61, Pl. XCV, *mes.*, have a forward extension such as is shown in Fig. 146, Pl. CVI, *som.* In front of the plate the mesoderm consists of scattered cells, which in

subsequent stages form the head mesoblast masses. The mesoderm plates give rise to somites and cœlom. The forward continuation of the cœlom (pericardial cavity) is derived from the head mesoblast, but does not come into existence until after hatching. The formation of the head mesoderm and pericardial cavity will be considered later, and for the present the cœlom, as contained in the trunk, will only be described.

The formation of the cœlom in the Bass takes place in a different way from that followed in the Trout. In the latter the embryo is not compressed laterally to such a great degree, so that the mesoderm plates lie in a more or less horizontal plane, and the cœlom mesoblast is divided from the somites in much the same way as in a bird. In the Bass the great lateral compression leads to a deviation from this mode of forming the cœlom, the deviation being probably a very common one amongst Teleosts.

Three stages in the formation of the cœlom are shown in Figs. 67, Pl. XCVI (35 hours), 75, Pl. XCVII (39 hours), 94, Pl. XCIX (45 hours). In Fig. 67 (compare the earlier stage, Fig. 61, Pl. XCV) the embryo has already undergone great lateral compression, and the mesoderm plates are now inclined at an angle of 45° to the surface. There is already present in this stage a shallow longitudinal furrow which tends to divide the plate into two parts, the somite mesoderm (*som.*) and the cœlom mesoderm (*coel.*). The furrow deepens as the next stage, Fig. 75, shows, and finally completely divides the plate into cœlom and somites, Fig. 94. (It may be said here that during the formation of the cœlom the somite mesoderm is at the same time dividing transversely into somites.) The cœlom as thus formed consists of a two-layered plate of flattened cells. The layers are not sharply separated, and during embryonic life it is only at the inner angle, where the Wolffian duct is constricted off, that a true cavity appears between them. The condition of the cœlom (*coel.*) at the time of hatching is seen in the successive sections, Figs. 126, 127, and 128, Plates CII and CIII. Fig. 128 is the most anterior, and on comparing it with Fig. 94 it is seen that the diminution in size of the yolk has brought the cœlom into nearly a horizontal plane. In the posterior part of the body, where the embryo has been entirely folded off from the yolk (Fig. 126), the lateral halves of the cœlom have met beneath the alimentary canal, and the somatopleure and splanchnopleure are sharply marked off from each other. The cœlom extends as far back as the anus, but at no time any further.

During the first three days of larval life the cœlom becomes transformed into something like its adult condition. A cavity appears between the somatopleure and splanchnopleure, in the immediate neighborhood of the alimentary canal (Fig. 136, Pl. CIV, 86 hours). The cœlom then extends beneath the canal (Fig. 138, Pl. CIV, 100 hours, and Fig. 139, Pl. CV, 112 hours) and the two halves ultimately meet, the ventral mesentery being absorbed. The gradual flattening which the cells composing the cœlom wall undergo may be traced in the figures 136, 138, Pl. CIV, and Fig. 141, Pl. CV. The next step taken by the cœlom is to grow down between the ectoderm and the yolk, on each side (Fig. 141, Pl. CV). By this time the liver has not only begun to develop (Fig. 138, 1) but has come to lie between the cœlom and the yolk, and hence the cœlom in its growth round the latter also envelops the liver. This is shown in Fig. 141, Pl. CV (136 hours) and in Fig. 145, Pl. CV (160 hours, ventral mesentery absorbed). When the two halves of the cœlom eventually meet in the median ventral line beneath the combined mass of liver and yolk (at x in Fig. 145) another ventral mesentery will be established. But it is plain that the new ventral mesentery will be only a continuation of the one which has been formed and absorbed

between the alimentary canal and yolk in Fig. 145. It therefore becomes evident that the growth of the cœlom round the yolk, begun in Fig. 141, is merely a part of the general growth of the cœlom round the ventral surface of the alimentary canal.

Near its ventral edge the somatopleure shows in the larval stages a band-like thickening (*m. b.*, Figs. 141 and 145) which looks in some respects like a muscle band.

Wolffian duct.—It is generally agreed that the Wolffian duct arises in the Teleostei as a fold of the cœlom. The formation of the duct begins anteriorly and travels back. Anteriorly the layers of the cœlom separate so as to inclose a true cavity, and there is formed a well-marked diverticulum (*w. d.*, Fig. 103, Pl. C). But there is no stage in which the duct exists along its whole length as a diverticulum. This may be due to the possible fact that as quickly as the duct is formed it is constricted off. The appearances indicate, however, that in its posterior half the duct is constricted off from the cœlom as a solid mass, the cells of which are radially disposed round an ideal lumen. The position and character of the duct, after separation from the cœlom, are shown in Fig. 110, Pl. CI, *w. d.*, at the time of hatching, in Figs. 126, Pl. CII, 127, Plate CIII. At the time of hatching the ducts extend as far back as the anus, but do not form a urinary bladder. The entire course of the duct is straight, and at its anterior end it opens into the cœlom.

The urinary bladder begins to form shortly after hatching by the fusion of the posterior ends of the ducts. It is very thin walled and opens just behind the anus. The only other step in the later development of the duct that I have observed is the formation of an anterior loop. On the second or third day after hatching, the anterior end of the duct bends round and runs posteriorly for a short distance. This is shown in the three successive sections, Figs. 143, 144, and 145, Pl. CV, of which Fig. 143 is the posterior. The opening of the duct into the cœlom (Fig. 144) at this stage could not be made out with certainty, but the part of the duct which I have represented as opening is morphologically the anterior end, and in an earlier stage this end very plainly opened into the cœlom.

Somites.—The marking off of the somites begins at about the same time as the separation of the cœlom. It begins anteriorly, but whether the first somite formed is the true anterior one I do not know. The somites are marked off by dorso-lateral constrictions (Fig. 98, Pl. CXIX, surface view, and Fig. 85, Pl. XCVIII, vertical longitudinal section to one side of median line) from which planes of division run into the substance of the mesoderm plates. The somites are, it is needless to say, solid. Hoffmann (17) describes them in the Trout as hollow, but he stands alone in this opinion.

The formation of somites travels antero-posteriorly, and during the greater part of embryonic life there is at the posterior end of the embryo, on each side, a quite long tract of undivided mesoderm (*un. mes.*, Fig. 85, Pl. XCVIII, and Fig. 98, Pl. XCIX) which at the tip of the tail ends in the caudal mass. New somites are constantly split off from the anterior end of the undivided mesoderm, and consequently the formation of somites and their gradual alteration may be studied in the posterior part of a single embryo quite as well as in corresponding parts of different stages. At the time of hatching there remains only a very little of the undivided mesoderm, the somites extending nearly to the tip of the tail.

In Fig. 98, Pl. XCIX, and Fig. 85, Pl. XCVIII, the somites next the undivided mesoderm are the younger, and on going forward it is seen that they gradually undergo certain changes of shape. When the somite is first formed, it is constricted off from the

mesoderm plate as a rectangular mass placed at right angles to the long axis of the body, Fig. 98. The vertical planes of division separating it from the mesoderm behind and the somites in front are simple planes (Fig. 85), and in transverse section the somite is undivided (Fig. 109, Pl. C). All that is changed as the somite grows older. Fig. 98 shows that the somites become inclined to the long axis of the body, the division planes running from without and posteriorly; Fig. 85 that they become bent forwards at about their middle; and Fig. 110, Pl. XCVII, that each somite becomes constricted into a dorsal and ventral portion (corresponding to the dorso-lateral and ventro-lateral trunk muscles).

While the somite is undergoing the changes of shape just described it also passes through a histological metamorphosis. The mesoderm plate, before the formation of somites begins, is made up of irregularly polygonal cells, which at the surface approach the cubical shape and give the plate a smooth bounding surface. The posterior remnant of the mesoderm plate (Figs. 85 and 98, *un. mes.*) preserves these characteristics, but the bounding cells become more decidedly columnar. A transverse section of the undivided mesoderm is shown in Fig. 90, Pl. XCVIII. When the somite is first constricted off, it is consequently made up of polygonal cells (Fig. 86, Pl. XCVIII, more highly magnified view of one of the posterior somites of Fig. 85, and Fig. 109, Pl. C, transverse section) and has on all sides a smooth bounding surface.

During the development of the somite the polygonal cells elongate in the direction of the chief body axis, and it finally is brought about that each cell stretches from the anterior to the posterior surface of the somite. In Fig. 87, Pl. XCVIII (more highly magnified view of one of the anterior somites of Fig. 85), the cells have undergone this elongation. Each of these long cells becomes transformed into a muscle fiber.

When the somite is first formed it is, as I have said, undivided in transverse section and has on all sides a smooth limiting surface. The smooth surface is lost on the proximal side of the somite (Fig. 94, Pl. XCIX), many of the cells coming to jut out in an irregular fashion. The next change to be described is the division into dorso-lateral and ventro-lateral muscle tracts. The somite constricts in a plane about opposite the notochord (Fig. 110, Pl. CI), and the tracts thus formed (*d. l. m.* and *v. l. m.*) are made more distinct by the existence of the cells *c. t.* While the remaining cells of the somite (exclusive of possible migratory cells, in regard to which I have no satisfactory observations) become transformed into elongated muscle cells, with large conspicuous nucleoli, the cells, *c. t.*, remain small, have inconspicuous nuclei and nucleoli, and form, as shown in the figure, a dividing wedge between the two muscle tracts. I really do not know what becomes of these cells, since the somite retains throughout embryonic life the character shown in Fig. 110. Sections through the larval stages suggest, however, that they become transformed into connective tissue. At least in the larva the muscle tracts are separated by a few scattered cells (Fig. 136, Pl. CIV).

The transformation of the elongated somite cells into muscle cells takes place after hatching, though, as is well known, the body is capable of strong muscular contractions before this time. Oscar Hertwig has described the metamorphosis which the homologous cells in *Triton* undergo (Lehrb., p. 270). In *Triton* distinct muscle fibrils appear in the cell protoplasm, first appearing in the peripheral part of the cell, but gradually forming in the inner portion also, until the whole cell is transformed into a bundle of fibrils. The development of the muscle cells in the Bass is of a

somewhat different character, in that the muscle substance is not formed as separate fibers, but as (apparently) homogeneous masses. During the first day of larval life, the peripheral part of the hitherto protoplasmic cell becomes transformed into three or four masses of muscle substance, separated by strands of protoplasm (Fig. 137, Pl. CIV, four muscle fibers from somites of Fig. 136). The protoplasmic strands meet in an axial remnant of protoplasm, in which is contained the nucleus. In a subsequent stage of development (Fig. 142, Pl. CV) the protoplasmic strands have disappeared and the amount of axial protoplasm at the same time has grown less, the great bulk of the cell having now become muscle substance. This is the condition of the fibers in the oldest larva I have studied.

The "intermediate cell mass" to which the somite is said to give rise in some fishes (Trout, Oellacher, Henneguy) does not exist in the Bass. Ziegler, who has carefully studied this structure (47), did not come to a positive conclusion in regard to its origin, but found that after giving off a number of blood cells it formed the "stamm vene" (fused cardinals) in the Salmon. It is undoubtedly absent in many fishes: *Serranus*, *Engraulis* (Wenckebach, 43), *Labrax* (Ziegler), and, as Ziegler says, has no homologue in other vertebrate groups. In those fishes in which it is absent, the vessels elsewhere formed by it are probably formed by scattered cells, as is the case with the aorta in the Bass. Ziegler's manner of looking at the structure commends itself; it is a part of the general Bildungs-gewebe (represented for the rest by wandering cells), which in some fishes early acquires an individuality as an anlage for certain great vessels (47).

In the Bass, as in other Teleosts, almost the entire somite goes to build up the great trunk muscles. What relation the cells, which subsequently form the skeleton, bear to the somites I am quite unable to say.

Mesoderm of the head.—Hoffmann (17, p. 26, 1883) says, without describing his observations, that the mesoderm of the head is undoubtedly segmented in the Teleosts. I have, however, not found any trace of segmentation in this part of the mesoderm, as the following description of its development will show. It is quite possible, however, that in this, as in some other respects, the small pelagic egg of the Bass is more secondarily modified than that of the Trout.

Before the closure of the blastopore the mesoderm in front of the paired plates (somite mesoderm) consists of scattered cells, and the total amount of it is small, as may be gathered from the transverse sections (Figs. 62, 63, and 64, Pls. XCV and XCVI.) The origin of this part of the mesoderm has already been described. The paired plates towards their anterior end dwindle in size, so that the transition from somite mesoblast to scattered mesoblast is not very distinct. When the somites begin to form, immediately after the closure of the blastopore, the scattered cells in the neck region (Fig. 62, Pl. XCV) increase in number and form a moderately compact mass (head mesoblast mass) in front of the somites, which extends forwards as far as the auditory invagination, and in front of that is continued as a collection of scattered cells. The condition of the head mesoblast at this stage is gathered from the series of sections, Fig. 68, Pl. XCVI (just in front of the somites), Figs. 69 and 70, Pl. XCVI (through auditory invagination), and Fig. 71, Pl. XCVII (through the branchial sense organ).

Forty-five hours, Figs. 95, 96, and 97, Pl. XCIX.—When the foregut closes in (compare Figs. 71, Pl. XCVII, and 95, Pl. XCIX) it is surrounded by scattered cells, but both

behind and in front of Fig. 95 the head mesoblast forms a compact mass. A section through the region of the branchial sense organ is shown in Fig. 96, Pl. XCIX, and on comparing this section with the earlier stage (Fig. 71, Pl. XCVII) it is seen that the head mesoblast masses have grown forwards. Still farther in front (Fig. 97, Pl. XCIX) the mesoblast consists of scattered cells.

The compact head mesoblast (head mesoblast masses) continues to increase in amount and grow forwards. At the time of hatching it extends up to the eyes. A series of sections (Figs. 127–134, numbered from behind forwards) through this stage will illustrate its condition. Fig. 128, Pl. CIII, is through the extreme anterior somite region. Compared with Fig. 127, it is seen that anteriorly the somites decrease greatly in size, and also that they come to lie beneath the medulla. Just in front of this section the somites come to an end and are followed by the head mesoblast masses, with which the body cavity is continuous (Fig. 129, Pl. CIII). Still further in front we come to the gill-slit region; Fig. 130, Pl. CIII, is, on the right side, through the slit, and on the left side just behind it. Comparing this figure with corresponding sections through earlier stages (Figs. 95, Pl. XCIX, 114, Pl. CI), the marked increase of mesoblast underneath the foregut is noticeable. The successive sections in front of the foregut, Figs. 131, 133, and 134, sufficiently indicate the condition of this part of the head mesoblast.

The pericardial cavity does not develop until after hatching. The cells which inclose it are split off from the under surface of the head mesoblast masses.

The development of the head mesoblast in the Bass, from a few scattered cells which proliferate and give rise to compact masses, which gradually acquire a greater forward extension, is evidently an extreme case of cœnogeny, and makes any attempt to study the early morphology of the head in such a fish as the Bass an almost hopeless task.

Mesoblast of the pectoral fins.—The pectoral fins do not form protuberances until a couple of days after hatching, but the mesoblast which gives rise to them begins to accumulate in the last few hours of embryonic life. Ziegler (47) has described the mesoblast of the fins as in direct continuity with, and as derived from, the head mesoblast. In the Bass there is no direct continuity between the two. On the contrary the accumulation of cells which gives rise to the fins (*pec. f.*, Fig. 136, Pl. CIV) is intimately associated with the body cavity. On passing forwards from the section represented in Fig. 136, the fin mesoblast comes to an end, the body cavity drawing away from the edge of the embryo and assuming an appearance about as shown in Fig. 127, Pl. CIII. Farther forward the head mesoblast begins. It is quite possible, however, that the lack of continuity with the head mesoblast is only apparent, and that cells may migrate (a few at a time so as to escape observation) from the head mesoblast to the position of the fins, though as to the probability of the supposition I have nothing to say. In a later stage (Fig. 139, Pl. CV, *pce. f.*) the intimate association of the fin mesoblast with the body cavity still exists, and as before there is no direct connection with the head mesoderm.

IX. HEART; AORTA; SUBNOTOCHORDAL ROD.

Heart.—During embryonic life the heart consists of a flattened sac lying to one side of the median line, in the space between the mesoderm and periblast (Figs. 133, Pl. CIV, and 151, Pl. CVII, *h*). The sac is composed of cubical cells, and is open

along one side over the greater part of its extent. Posteriorly, however, it forms a closed tube (Fig. 117, Pl. CII, *h*, arterial end of heart). The sac contains a plasma, which takes a light stain, and amœboid cells. The heart begins to beat while in this condition.

In regard to the origin of this simple embryonic heart and its further development I may say that my observations on the Bass differ in so many points from the careful accounts given by Henneguy (18), Ziegler (47), and Oellacher (33), of the formation of the trout's heart, that I prefer reserving my description until I have had an opportunity of studying the process in the *Salmonidæ*.

Subnotochordal rod and aorta.—Before the alimentary canal closes in ventrally there is found lying above it a single row of cells (*s. n. r.*, Fig. 76, Pl. XCVII). The cells are flattened dorso-ventrally, and their position with respect to the entoderm cells, from which it is sometimes difficult to distinguish them, makes it safe to conclude that they are the uppermost cells of the enteric fold, which have separated from the rest of the entoderm. There is thus in the Bass a homologue of the entodermic subnotochordal rod of Selachians, as there is in the Trout (Henneguy). The further relations of the rod in the Bass are extremely complicated. It becomes intimately associated with certain cells which form the aorta, though I do not believe that it enters into the composition of the vessel itself. I have thought it worth while to set down my observations on the development of the aorta, though they do not lead to a conclusion regarding the origin of the cells which form it.

To the subnotochordal rod are added other cells which form a string, some three or four cells in section, *a. an.*, Figs. 92 and 93, Pl. XCIX, and 103, Pl. C. The origin of these cells I do not know; sometimes I have thought them hypoblastic, and again mesoblastic. The probability is undoubtedly in favor of the latter origin. Occasionally the new cells added take a shape and position precisely like the subnotochordal cells (Fig. 104); usually, however, they are of an irregular shape. During the formation of this solid string of cells very few wandering cells are to be seen, though in a little later stage (Fig. 110, Pl. CI) they are conspicuous in the spaces between somites, chorda, etc. Whatever be the origin of this string of cells, it is a true "aorten strang" (Oellacher), in that it develops into the aorta. The cells, which compose it, separate so as to inclose, at first in an irregular fashion, a central space (*aor.*, Fig. 110), the aorta cavity. In subsequent stages the bounding cells become flattened and completely inclose the cavity. As I have said, I do not think the subnotochordal cells take part in forming the aorta, for even after it has become a perfectly closed tube they may sometimes be seen in their old position just above the vessel.

The atrophy of the postanal gut takes place from before backwards. As it progresses, there is left in the place of the gut a string of cells (one or two thick), which constitutes the caudal part of the subnotochordal rod (Figs. 101 and 109, Pl. C; Fig. 111, Pl. CI, *s. n. r.*). With this rod are associated some few amœboid cells, the origin of which is unknown (Figs. 101 and 109), but which are probably concerned in the formation of the aorta in this region. The formation of the aorta in the tail, like the atrophy of the postanal gut and formation of the subnotochordal rod, progresses from before backwards. There is no previous formation of a solid string of cells. In the section Fig. 112, Pl. CI, the subnotochordal cells, above the aorta, were unusually distinct.

X. GENERAL MORPHOLOGICAL QUESTIONS.

Concrescence.—The theory of His, that the vertebrate embryo is formed by the concrescence of two halves along the median dorsal line, has drawn many of the arguments used for its support from the development of the Teleosts; and in the study of any fish, the presence or absence of indications of concrescence must be looked on as one of the more important general questions involved. However attractive in the abstract the theory may be, I have failed to find in the Bass development any facts which should induce one to accept it, and the arguments commonly used in its favor seem to be very far from conclusive. Indeed, the only good argument I know of is Ryder's observation (35) that in *Elacate* the extra-embryonic germ ring gives indications of being divided up into somites. But I do not think this point can be made much of until Professor Ryder publishes a more detailed account of the embryos he observed, for the exact relations of the several parts of the embryo at the tail end can scarcely be ascertained from the existing account. Henneguy has in his last paper (18) reviewed the arguments for the concrescence theory, and as I agree in the main with his criticism it is unnecessary for me to recapitulate them. I will therefore simply describe the growth of the Bass embryo.

In the growth of the blastoderm round the yolk, the head end of the embryo does not remain a fixed point, the body lengthening in an antero-posterior direction, as His supposed. On the contrary, the tail end of the embryo (posterior pole of the blastoderm, *p. p.*, Fig. 35, 36, and 38, Pl. XCII) remains a comparatively fixed point, as Oellacher first showed, while the anterior pole of the blastoderm travels rapidly round the yolks (arrows, Figs. 35 and 36). The point where the blastopore closes is thus but a short distance from the original position occupied by the posterior pole of the blastoderm. Owing to the constant position of the single oil globule, these facts can easily be made out (compare Figs. 35, 36, and 38).

The growth of the embryo itself is more complicated, but still susceptible of what seems an accurate analysis. On comparing Figs. 35 and 36, it is seen that while the posterior pole of the blastoderm remains comparatively fixed, the head end (*h. e.*) of the embryo follows, though at a much slower rate, the anterior pole of the blastoderm in its growth round the yolk. The comparison of the two figures inevitably leads to the conclusion that the increase in length, which the embryo undergoes in passing from one stage to the other, is due to intussusception and not to concrescence. Extending the comparison to the later stage (Fig. 38, Pl. XCII, just before the blastopore closes) it is seen that the increase of length, which the embryo undergoes between the stages represented by Figs. 36 and 38, is brought about in a different way from that between Figs. 35 and 36. This is shown by the following examination: At the beginning of the older period (Fig. 36) the head end and tail end of the embryo are approximately equidistant from the oil globule, and at the end of the period (Fig. 38) the case is the same. The head end of the embryo has therefore continued to grow round the yolk, as in the period Figs. 35 to 36, and the body has also been lengthened at the opposite end in the opposite direction. The increase in length at the tail end of the embryo deserves especial attention. The great increase in length, which the body undergoes by the growth round the yolk of the head end of the embryo (Figs. 35 to 36, and also Figs. 36 to 38) can only be explained as ordinary growth by intussusception. If this is so, it is perfectly fair to assume, until the contrary is proved, that the comparatively

small increase in length, which the body receives at the tail end, is due to the same sort of growth. And I have no doubt that this is true of the greater part of the caudal increase. But the development, during the closure of the blastopore, of what has been called the primitive streak clearly leads to the conclusion that, as the blastopore closes, the germ ring is drawn into the tail end of the embryo, which is thus progressively lengthened, the final addition (of this sort) to its length being the incorporation of the secondary caudal mass, *sec. c. m.*, Fig. 65, Pl. XCVI. The formation of the teleostean primitive streak is obviously so similar to that of Amphibia (compare Schwarz, 39) that the two must be regarded as homologous. In *Triton* (Hertwig, 20) the blastopore closes in a slit-like fashion (see Fig. 7), leaving at its lower end a small opening, through which protrudes the *dotterpropf.* The line along which the blastopore closes is indicated after closure by a groove, *p. g.* Now compare with the diagram of the *Triton* blastopore the section given in Fig. 65, Pl. XCVI. The primitive streak in the Teleost represents the line of closure in *Triton;* at the posterior end of the streak there is the same opening; and the opening is plugged up by a *dotterpropf.* The formation of the primitive streak in the Amphibia, by a true concrescence of the blastopore lips, is undoubtedly the ancestral method, of which the process made use of in the Bass must be regarded as an embryonic modification.

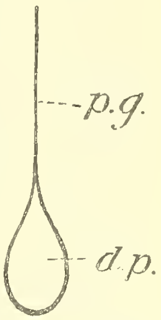


Fig. 7.—Diagram of closing blastopore of Triton.

To sum up, the growth of the embryo takes place, as I believe, in the following manner: The great increase in length is acquired by the head end of the embryo following the anterior pole of the blastoderm in its growth round the yolk. The embryo is also lengthened in a much less degree by the movement of the tail end in the opposite direction. The growth in each of these cases is brought about by intussusception. The blastopore closes in a manner which is clearly a modification of concrescence, and gives rise to the terminal portion of the embryo in which there is a median fusion of layers.

The concrescence theory of His certainly receives no confirmation in the development of the Bass. All the facts regarding the growth of the embryo that I have observed are incompatible with it, the only part of the embryo which is formed by concrescence being the posterior end, behind Kupffer's vesicle; and the increase in the length of the embryo, by the addition to it of the primitive streak, is obviously a secondary modification resulting from the transformation of a holoblastic egg (like the Amphibian) into a meroblastic egg. This is made plain by an examination of Fig. 65, Pl. XCVI. In the ancestral holoblastic embryo the primitive streak did not lie horizontally, but more or less vertically; *i. e.*, it represented the posterior end of an embryo, in which the yolk was comparatively small and went to form the ventral wall of the gut. With the formation of the large, purely nutritive, yolk, the posterior end of the embryo came to lie in a horizontal plane, and so added to the length of the embryonic body.

Among recent advocates of the concrescence theory (Ryder, 34, 35; Cunningham, 8) the closure of the blastopore in Teleosts has been regarded as affording strong evidence of the truth of the theory. But it seems to have been assumed, without any satisfactory grounds, that the tissue of the germ ring, as it is drawn into the embryo, comes to lie along the notochordal line. Cunningham's argument in brief is as follows: (1) the non embryonic part of the germ ring disappears; (2) it is not absorbed, and must consequently be drawn into the embryo; (3) the latter is hence formed by

concrescence. I fully admit 1 and 2, but the Bass development shows that the primitive streak is the only part of the embryo which it is fair to conclude is formed from the non-embryonic germ ring, and hence Cunningham's conclusion (3) is entirely inadmissible. Cunningham's whole conception of the non-embryonic germ ring is, as I shall try to show, an erroneous one.

Teleostean gastrulation and the significance of the germ ring.—The Teleostean gastrula is such a complicated embryonic form that it has given rise to many interpretations, and the disagreement as to the proper one still continues. So much is this the case that the light which the Teleostean development is capable of throwing on the embryology of the Amniotic vertebrates has been greatly obscured. I give a brief review of the several theories on this head, ending with Ziegler's, which, besides affording a satisfactory explanation of the Teleost embryo itself, makes practicable so many comparisons with both Ichthyopsidan and Amniotic embryos that it leaves little to be desired. The only obstacles in the way of the theory have been the lack of exact knowledge with regard to Kupffer's vesicle and the meaning of the extra embryonic germ ring.

Haeckel (19), who witnessed the inflection of the blastoderm edge to form the germ ring, regarded the Teleostean gastrula as a true discogastrula; that is, he believed, the inflected layer met in the center (as in Fig. 8), forming a complete layer beneath the ectoderm. The two-layered embryo thus formed he called a discogastrula, the yolk lying (morphologically) in the gastrula cavity. Haeckel's conception is based in the first place, as has long been recognized, on wrong observations; the invaginated tissue does not form a complete layer beneath the ectoderm, but remains incomplete in the center (Fig. 9). In the second place Haeckel's explanation, as Balfour pointed out (Elasmo. Fishes, p. 277), makes it impossible to regard the yolk as a part of the embryo, whereas the comparative embryology of vertebrates makes it absolutely certain that the yolk of meroblastic eggs is a part of the embryo and has been derived from the yolk cells of some such form as the Amphibian blastula. While Haeckel's theory, as he presented it, no longer receives any support, it has obviously influenced the views of more recent writers, such as Ryder and Henneguy. According to Ryder the Teleost gastrula has been derived in the following manner:

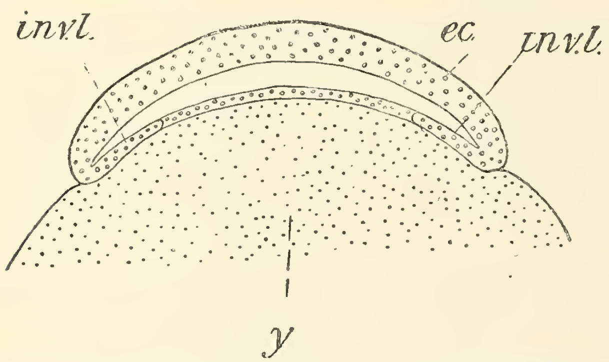


Fig. 8. Diagram to illustrate Haeckel's idea of teleostean gastrulation—*y.*, yolk; *inv. l.*, invaginated layer; *ec.*, ectoderm.

> A gradual loading of the entoblastic pole of the blastula (*Amphioxus* blastula) with yolk causes the latter to be constricted around its equator in the course of development, thus leading to the formation of a blastodisc with an inflected two-layered margin. (35, p. 493.)

The incomplete center of the inflected under layer, to which Ryder gives the convenient name of discopore, is "homologous with a circular opening which might be produced by a rupture near the center of the inflected entoblast of the gastrula of *Branchiostoma*." It will be seen that while Ryder agrees with Haeckel in believing

that the yolk fills the archenteron, he on the other hand regards the yolk as representing a part of the entoderm of the *Amphioxus* gastrula.

Henneguy's theory is practically the same:

La gastrula des poissons osseux est, comme l'a bien vue Haeckel, une véritable discogastrula qui par son mode de formation et par sa constitution, se rapproche beaucoup plus de la gastrula type de l'Amphioxus que celle des autres Poissons (18, p. 596). Si l'on suppose, en effet, la blastula de l'Amphioxus ouverte à sa partie inférieure et s'invaginant autour d'une sphère (vitellus) on aura une image exact de la gastrula des Téleostéens. L'intestin primordial, le protogaster, est rempli par la masse vitelline (p. 597).

It will be seen that both of these writers refer the Teleost gastrula directly to that of *Amphioxus*, and accordingly regard the ingrowth of cells round the entire edge of the fish blastoderm as representing the invagination of *Amphioxus*, the cavity of the fish gastrula being filled with yolk, which has been derived from the bottom cells of the *Amphioxus* archenteron. It can not be denied that this theory offers an explanation of the early Teleost gastrula (diagram, Fig. 9), but it becomes utterly unsatis-

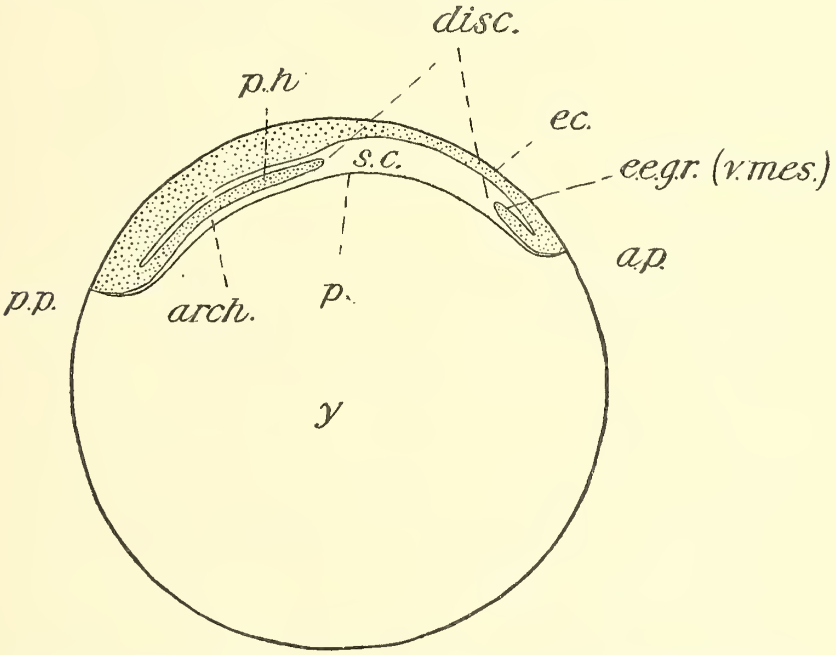


FIG. 9.—Diagram of early Teleost gastrula—*p. p.*, posterior pole; *a. p.*, anterior pole; *p. h.*, prim. hypoblast; *arch.*, archenteron; *p.*, periblast; *s. c.*, segmentation cavity; *disc.*, discopore; *ec.* ectoderm; *e. e. g. r.* (*v. mes.*), extra-embryonic germ ring (ventral mesoblast).

factory as soon as what Balfour has called (7) "the asymmetry of the vertebrate gastrula" begins to appear in the fish embryo. For the Teleost gastrula of Ryder and Henneguy is a symmetrical gastrula, and they are consequently unable to explain why it is that (continued) invagination takes place at one pole of the blastoderm (*p. p.*), while the other pole (*s. p.*) grows epibolically round the yolk. There are numerous other difficulties in the way of the theory, which become apparent as soon as the attempt is made to derive in detail the older Teleost embryo (Fig. 10, p. 264, and Fig. 65, Pl. XCVI) from a gastrula such as the theory assumes. But the greatest objections are, first,

the total absence of intermediate forms between the gastrula and that of *Amphioxus*, and second that the theory leads us nowhere; it does not admit of any exact comparison between the teleostean embryo and those of other vertebrates.

Kupffer's theory of gastrulation (25, 26) is very different, but stands in complete opposition to the facts. According to Kupffer the vesicle, which bears his name, arises by an invagination from the ectodermal surface, and alone represents the *Amphioxus* invagination. The functional entoderm is derived from the yolk and is regarded as a structure which has gradually replaced the invaginate entoderm.

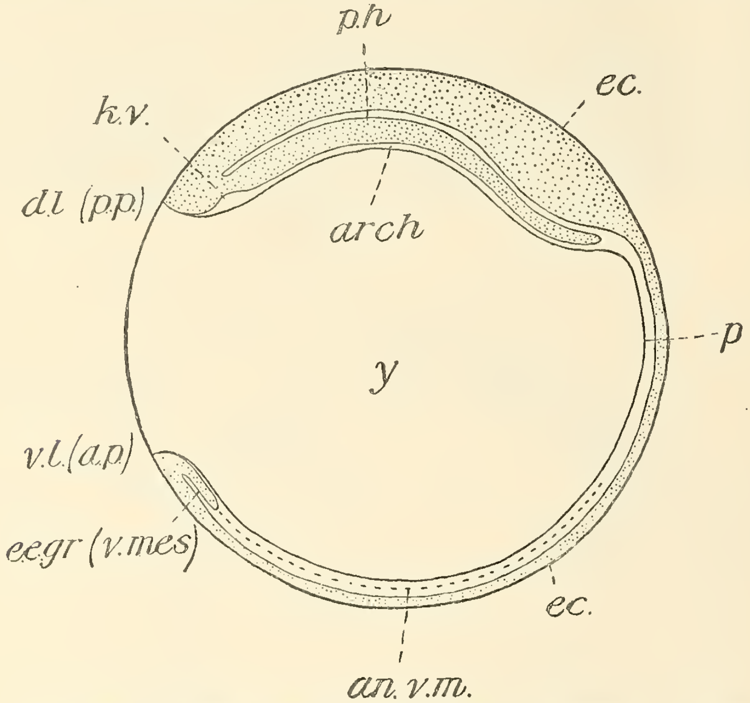


FIG. 10.—Diagram of Teleost gastrula, not long before blastopore closure—*d. l.* (*p. p.*), dorsal lips (post. pole) of blastopore; *v. l.* (*a. p.*), ventral lip (ant. pole) of blastopore; *k. v.*, Kupffer's vesicle; *arch.*, archenteron; *p. h.*, prim. hypoblast; *ec.*, ectoderm; *p.*, periblast; *e. e. g. r.* (*v. mes.*), extra-embryonic germ ring (ventral mesoderm); *y*, yolk; *an. v. m.*, extent of tract of ventral mesoderm in ancestor.

Kollmann (29) entertains the strange and difficult view that the discopore (*disc.*, Fig. 9) is the blastopore. His theory has already been criticised by Ryder (35, p. 493), with whose objections I agree. There is really nothing to support the theory; the generalized diagram of the meroblastic gastrula, which Kollmann gives, is a very different form from the Teleost embryo, and an acceptance of his homology of the discopore with the blastopore makes it impossible to understand any part of the further development. The closure of the blastoderm edge at the tail end of the embryo becomes incomprehensible, while the position of the "blastopore" (discopore) lip directly under the head of the embryo (when compared with its position in *Amphioxus*), and the fact that the "blastopore" (discopore) never closes, remain absolute mysteries.

To Ziegler (48) is due the credit of having first instituted a detailed comparison between the teleostean and Amphibian gastrulas, for it is only through such a comparison that the intricacies of the fish development become comprehensible. Ziegler's

homologies are as follows: Yolk together with the periblast represents the yolk cells of the Amphibian gastrula; the invagination at the posterior pole of the fish blastoderm represents the invagination round the dorsal lip of the Amphibian blastopore, which forms the so-called chorda-entoblast; the gastrula cavity in the fish is morphologically between the invaginated layer and the periblast. Ziegler's theory is concisely stated in the following quotations (48):

Bei der Unke und den Salmoniden wird die Bildung der unteren Schichte am ganzen Rande der Keimscheibe eingeleitet; sie beginnt aber an der dorsalen Seite früher als an der anderen, und schreitet nur auf dieser fort, während sie im übrigen Umfang bald wieder sistirt wird.

Phylogenetisch ist das Entoderm der Teleostier nur der dorsale Theil des Darmdrüsenblattes; es entsteht aber aus demselben das ganze Darmepithel, indem es medianwärts aufstülpt, und darauf die so entstandene Rinne vom Dotter abgeschnürt wird.

Der bei diesem Vorgang in der Kiemengegend entstehende freie Raum zwischen Entoderm und Dotter entspricht einem Theil der Gastrula und Darmhöhle der primitiveren Entwicklungstypen; dasselbe gilt vielleicht von der Kupffer'schen Blase.

Accepting Ziegler's homologies, it will be seen that the whole course of the fish development becomes easy to understand. Starting with the blastula (Fig. 25, Pl. XCI, *s. c.*, segmentation cavity) and disregarding for the present the non-embryonic part of the germ ring, the primitive hypoblast (*p. h.*) which invaginates at the posterior pole (*p. p.*) of the fish blastoderm (Fig. 9) corresponds to the primitive hypoblast (*p. h.*) which invaginates round the dorsal lip of the blastopore in the frog gastrula (Fig. 11). The chief point of difference is the lack of continuity in the fish embryo between the inner edge of the invaginated layer and the yolk, easily explained as an adaptation to the method of forming the alimentary canal from the invaginated layer exclusively. The archenteron (*arch.*) lies between the primitive hypoblast (*p. h.*) and the periblast (Fig. 9, *p.* 263). In consequence of the absence of continuity between the yolk and the invaginate layer, the archenteron at its edge is not separated from the segmentation cavity (*s.c.*). The growth of the anterior pole of the blastoderm round the yolk (compare Figs. 9, *p.* 263, and 10, *p.* 264) represents the growth of the small cells round the yolk cells in Amphibian gastrulation. The closure of the blastopore takes place in the same way as in the Amphibia; there is formed a short primitive streak behind the position of the neurenteric canal (Kupffer's vesicle in Teleost); at the posterior end of the primitive streak the final closure takes place (the comparison must be made with those

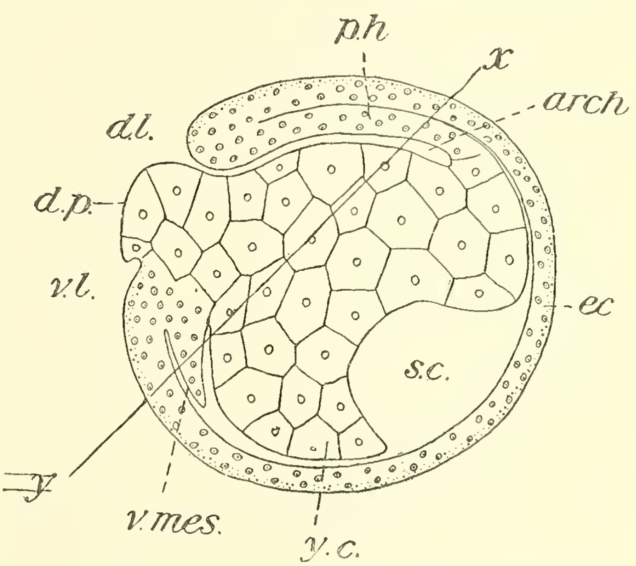


FIG. 11 (after Hertwig, 20).—Median longitudinal section through frog's gastrula—*d. l.*, dorsal lip of blastopore; *v. l.*, ventral lip of blastopore; *d. p.*, Dotterpropf; *s. c.*, remnant of segmentation cavity; *y. c.*, yolk cells; *ec.*, ectoderm; *p. h.*, prim. hypoblast; *arch.*, archenteron; *v. mes.*, ventral mesoblast.

Amphibia in which the posterior end of the blastopore does not persist as the anus, but closes), Fig. 65, Pl. XCVI, the blastopore remnant being plugged up in both types by the yolk.

The asymmetry which Balfour (7) showed to be a characteristic attribute of vertebrate gastrulation, is present in the highest degree in the Teleost gastrula. At the posterior pole of the blastoderm (dorsal lip of the blastopore) there is an extensive invagination, which gives rise to the roof of the archenteron. The opposite pole of the blastoderm (ventral lip of blastopore) incloses the yolk (=yolk cells=floor of archenteron) in an epibolic fashion. The cause of the asymmetry must be looked for in a peculiarly localized distribution of the yolk in the egg. The yolk not only lies in the hypoblastic part of the egg (so to speak), but in that part of it which corresponds to the *ventral* hypoblast of the gastrula. Consequently when the meroblastic blastula is perfected (Fig. 30, Pl. XCI) the so-called "blastoderm" contains not only the ectodermic half of the primitive simple blastula, but also contains one half of the hypoblast. This half of the hypoblast invaginates as it did in the yolkless ancestor, but the other half (yolk) must be inclosed epibolically.

The alimentary canal is formed from the roof of the archenteron exclusively. How this was effected is easy to see. The increase in size of the mass of yolk cells (of Amphibia) brought it about that the dorsal parts of the embryo were early folded off—some time before the alimentary canal was completed ventrally. The division of labor already far advanced between the dorsal and ventral hypoblast of the gastrula next took the final step: the dorsal hypoblast assumed the entire function of forming the gut, while the ventral hypoblast became transformed into pure food material. The yolk is consequently to be looked on as an organ of the gastrula which has lost its original function, but which in doing so became adapted to another function to which it owes its large size.

Up to this point the discussion of the extra-embryonic germ ring has been avoided. The interpretation of this part of the embryo is a mere corollary of Ziegler's conception of the gastrula, as originally stated (48). A comparison of the frog's gastrula (Fig. 11) with the fish gastrula (Fig. 10), after the preceding discussion, leads at once to the homology of the extra-embryonic germ ring, (*e. e. g. r.*) with the ventral mesoblast of the frog (*v. mes.*) In my preliminary communication (46) I made the following statement: "With reference to the meaning of what may be called the nonembryonic part of the germ ring, Ziegler is by no means clear, though the interpretation seems to me a mere corollary of the foregoing (Ziegler's) propositions." Since writing this I have received a letter from Professor Ziegler which, read in connection with his brief mention of the point in his second paper (47), satisfies me that he has held for some years the view of the extra-embryonic germ ring to which the present piece of work has led me. It gives me pleasure to find that as regards this point as well as in the general interpretation of the gastrula, I have been led to the same conclusions as Professor Ziegler. The point is one, however, which deserves a somewhat ampler notice than Ziegler gives it.

The adherents of the concrescence theory in vertebrates regard the extra-embryonic germ ring as hypoblastic. Thus Agassiz and Whitman (1) state their opinion as follows: "We think that what we have described as the entodermic ring (germ ring) corresponds to the chorda-entoblast of Rana; and it seems plausible that the periblast should correspond to the 'Darmentoblast.' On this view we should expect the periblast to take some share in forming the alimentary canal, which can not be admitted if

our observations are correct" (*p.* 79). With respect to concrescence this statement is made:

> It appears quite certain to us that the principle of concrescence underlies the formation of the embryo. The concrescence appears under the disguised form of a migratory movement of the cells, which accompanies the epibolic growth of the blastoderm. (P. 74.)

Now, before accepting the hypothesis that the extra-embryonic ring represents chorda-entoblast, we must be satisfied that the two halves of the ring meet along the chorda line. And I have tried to show that in the Bass there is no reason for believing this. Until the concrescence is actually proven, I do not think this manner of looking at the germ ring is admissible.

But, if the concrescence theory were established, even then it would scarcely be an explanation of the germ ring to call it chorda-entoblast. For at all events a part of the ring occupies a ventral position with respect to the blastopore (*e. e. g. r.*, Fig. 10, *sec. c. m.*, Fig. 65, Pl. XCVI), and it is obviously impossible to regard this part as chorda-entoblast. Evident as this would seem to be, Cunningham has been curiously misled into regarding the whole ring as equivalent to dorsal hypoblast, because it eventually comes to occupy a dorsal position with respect to the yolk. Cunningham's position is fairly given in the following quotations (8):

> The whole of the embryonic ring thus belongs to, and is formed into, the dorsal region of the embryo. (P. 17.)
>
> It is probable that the inflected ring in the Teleost is the dorsal hypoblast. It has already been pointed out that the whole of the inflected ring comes to lie beneath the axis of the embryonic rudiment, between that axis and the yolk. The invaginated layer thus ultimately occupies the same position as the layer in the blastoderm of the bird, to which the name hypoblast was first applied. (P. 20.)

With respect to the occurrence of concrescence, Cunningham gives no actual evidence, and there is nothing in his account which would cause me to believe that the growth of the embryo, in the fishes he studied, takes place in a different way from that of the Bass. The fact that the whole of the germ ring is absorbed into what Cunningham calls the dorsal region of the embryo (more properly terminal portion) is surely no argument that the germ ring is equivalent to dorsal hypoblast. The morphology of the ring must be determined before the blastopore closes, and an ingrowth from the ventral lip of the blastopore can scarcely be called dorsal hypoblast.

A satisfactory explanation of the extra-embryonic germ ring can only be obtained by regarding it as mesoblast. The ingrowth from the dorsal lip of the blastopore in the Teleost consists of primitive hypoblast (mesoblast plates, chorda, roof of archenteron). This ingrowth is continuous with that which grows in from the ventral lip, and which consists of mesoblast. Precisely the same state of affairs is found in the frog (Fig. 11, p. 265), as may be gathered from Oscar Hertwig's account (20, p. 273) of its development:

> Müssen wir schliessen, dass am Urmundrand der Ektoblast in das Innere der Embryonal form hinein wuchert, und hier einerseits in einen Streif ihrer dorsalen Wand übergeht, der den Darm nach oben als Chorda-Entoblast begrenzt, andererseits *sich in den Mesoblast continuirlich verfolgen lässt.*

In the phylogeny of the fish gastrula the entoblast and mesoblast have suffered a very similar fate. In the case of the former the ventral entoblast has lost its function, the dorsal entoblast assuming the entire duty of forming the alimentary canal. Likewise the ventral mesoblast, which in the Amphibian grows forwards underneath the yolk cells and forms the ventral mesodermic tissues of the adult, has in the fish lost

its function. The causes which led to the loss are plain enough. The yolk sac remains very large long after active muscular movements begin (movements begin before hatching) and a ventral musculature beneath the yolk (which would occupy the position indicated by dotted line in Fig. 10, p. 264, *an. v. m.*) would consequently be of no service until late in larval life, when the sac should have disappeared. This being the case, a much more economical method of forming the mesoderm was to put a stop to the subvitelline ingrowth (*an. v. m.*) and allow the lateral plates to form the ventral as well as dorsal mesoblastic tissues. The ventral (subvitelline) mesoderm, having in this way lost its function in the Teleost, must be regarded as a rudimentary organ of the gastrula. It always remains very small, and does not form any special organ or set of organs in the embryo. Being present it is however made use of, and goes to form a mass of indifferent material (caudal mass) at the expense of which the organs in the tail develop.

The germ ring, *in toto*, according to the view which has just been given, is not a peculiarity of the Teleost. It is a feature which the Teleost gastrula owes to an ancestor more or less like the gastrula of Amphibia, but which has gained in the Teleost a distinctive character, owing to its appearance all round the lip of the blastopore at a time when the latter is very large.

Significance of the germ ring with respect to the amniotic gastrula.—The fact that the ventral mesoderm, which in Amphibia is an important organ of the gastrula, is in Teleostei reduced to a rudimentary organ round the edge of the blastoderm, acquires a peculiar significance when the still more complicated gastrula of amniotes comes up for explanation. The fundamental features of this gastrula, it seemed, were satisfactorily explained by the Balfour-Rauber hypothesis, according to which the primitive streak plus the blastoderm edge represents the blastopore, the dorsal lip of which is indicated by the neurentric canal. The manner in which these writers believed the primitive streak to have been phylogenetically formed, was thought to receive a confirmation from the actual concrescence of the blastoderm edge, which takes place in the Selachian embryo behind the neurentric canal. During the last few years, however, the tide has set against this hypothesis, and in the direction of a new one, the chief exponents of which are Kupffer, Cunningham, Oscar Hertwig, and Rabl.

Kupffer's work on reptiles (25, 26), in the course of which he found that in this group there is no primitive streak, but in its place a definite invagination, led to the first step in the new direction. Kupffer came to regard the reptilian "invagination" (prostoma) and its homologue the Sauropsidan (and mammalian) primitive streak as alone representing the blastopore; the edge of the blastoderm was looked on as totally independent of the blastopore and was explained in a very unique fashion.

Cunningham (8), Oscar Hertwig (22), and Rabl (38) have all adopted this view of what constitutes the blastopore in the Amniotic gastrula. Hertwig says in his Lehrbuch (p. 104):

> Als Urmund schlage ich vor nur diejenige Stelle des Keims zu bezeichnen, an welcher wirklich wie bei der Gastrulabildung des Amphioxus und der Amphibien, eine Einstülpung von Zellen stattfindet, wodurch die Furchungshöhle verdrängt wird.

Such a process, according to Hertwig, does not occur round the edge of the blastoderm, and is only found in the region of the primitive streak and the "prostoma" of reptiles. The edge of the blastoderm is hence not a part of the blastopore; it is—

> eine Besonderheit der meroblastischen Eier, die mit der Entstehung der partiellen Furchung auf das innigste zusammen hängt.

Hertwig's explanation of the blastoderm edge is practically the same as Kupffer's.

Rabl (38) states his position, which is identical with the preceding, by means of a neat comparison between the bird and the frog gastrula. The line *x–y*, in Fig. 11, p. 265, cuts the frog's gastrula in two parts. The part to the left corresponds to the Amniotic embryo, the part to the right to the Amniotic yolk. The blastopore (*d. l.–v. l.*) equals the primitive streak, all round which there is an ingrowth of cells. The part to the right of *x–y* becomes transformed entirely into yolk. Rabl does not offer an explanation of how the transition from one gastrula to the other was accomplished. All he says is, that the effect is due to the great increase in size of the yolk (yolk cell mass). The inference, however, is that he adopts Cunningham's explanation, and supposes an actual hernia to take place.

The only argument for the view of the Amniotic gastrula entertained by the above-mentioned authors is that all round the lip of the blastopore in the Amphibia, etc., there is an ingrowth of cells, and that round the prostoma of reptiles and primitive streak of birds and mammals there is the same ingrowth. The two structures it is concluded must therefore be homologous. It then becomes a question of how to explain the blastoderm edge. Two explanations of the structure have been offered, one by Kupffer which is substantially the same as that of Oscar Hertwig, and one by Cunningham to which Rabl seems inclined. Kupffer's explanation is contained in the following passage (26):

> Ich fasse also die Ausbreitung des Blastoderms über den Dotter als Blastulabildung auf. Der Abschluss dieser Bildung erfolgt um so später je grösser der zu umwachsende Dotter ist, und es tritt der Gastrulation vor Vollendung der Blastulabildung ein, *d. h.*, während ein Blastotrema [so-called Dotter-Blastoporus] noch vorhanden ist.

On analyzing Kupffer's view it will be seen that by "blastula" he means not a one-layered but a two-layered embryo. His theory is illustrated by the diagram, Fig. 12, in which *a–á* mark the blastoderm edge of an Amniote; *s. c.* is the segmentation cavity, and *y* is the yolk—the embryo being in what would commonly be called the blastula stage. Now the growth of the blastoderm over the yolk does not take place, according to Kupffer, in a true epibolic fashion, but is accomplished through the medium of a zone of tissue (Keimwall) in which the yolk cells (nuclei) become transformed into the cells of the two primary layers. Hertwig holds the same opinion (Lehrb., p. 105). If this be really the case in Amniota, two explanations of the process are possible: First, that it is a modification of the ancestral, epibolic growth (such as occurs in Teleosts), which view Kupffer and Hertwig would of

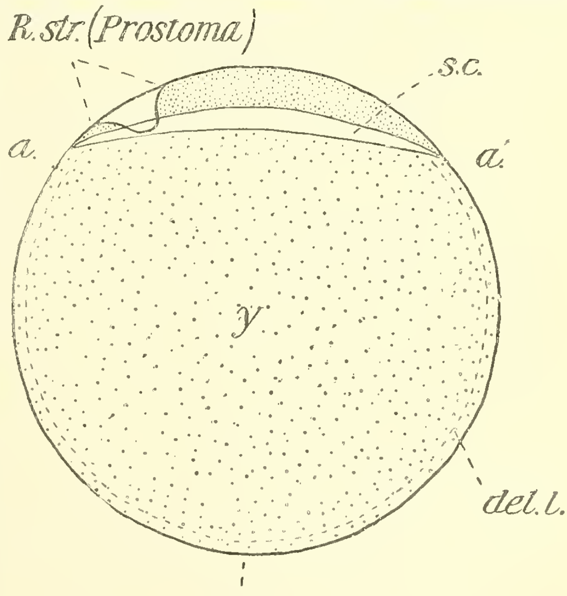


FIG. 12.—Diagram to illustrate Kupffer's theory of the Amniotic gastrula—*s. c.*, segmentation cavity; *y*, yolk; *a.* to *a.*, edge of blastoderm; *P. str.*, primitive streak (Prostoma of reptiles); *del. l.*, line along which, according to Kupffer, the yolk splits off ectoderm.

course reject, because it is equivalent to admitting the homology of the blastoderm edge in Teleosts and Amniotes, and consequently the correctness of the Balfour-Rauber hypothesis; secondly, that the process is, to refer it to simple embryonic forms, one of progressive delamination. It will be seen that Kupffer's hypothesis really implies the occurrence of the latter process, for when he explains the spreading of the blastoderm as the completion of the blastula stage, he really means that the yolk splits off ectoderm progressively from a and a' towards m. Thus, again to reduce the processes to their simplest forms, over one-half (yolk-half) of the blastula (Fig. 12, p. 269) delamination occurs; but in the other half there is a true invagination (region of prostoma and primitive streak). Neither Kupffer nor Hertwig illustrates his theory with diagrams, and since the embryonic processes dealt with are extremely complicated, it is a difficult matter to form a precise conception of their meaning. However, I think the analysis I have given is a perfectly fair one, and the result is evidently prejudicial to their theory. For the conclusion is that the Amniotic vertebrates have a blastula, which invaginates over one half and delaminates over the other. Such an embryonic form is nowhere known to occur, and the theory which is forced to assume its existence is in so far a weak theory and must give place to any other which can explain the facts by making use only of known processes.

The explanation which Cunningham gives to the blastoderm edge, and to which Rabl is logically forced, is much simpler than the hypothesis just discussed. It is equally objectionable, however, for it invokes a process never observed, and which is moreover *a priori* extremely improbable. Adopting as an ancestral form a gastrula like that of the frog, Cunningham supposes the Amniotic gastrula to have been derived as follows: The increase in size of the mass of yolk cells, instead of enlarging the blastopore (the result which one would suppose would naturally follow) produced a rupture in the ectoderm. In this way the lower surface of the yolk came to be exposed and the blastoderm edge was brought into existence, the latter being a purely secondary structure, dating no further back than the occurrence of the hernia.

The fact that, having once accepted Kupffer's homology between the primitive streak and the blastopore we are forced to assume the occurrence of such improbable embryonic forms and processes as have just been described, leads us to reconsider the older Balfour-Rauber hypothesis. The only objection to regarding the blastoderm edge as part of the original blastopore, is that round the latter there is an ingrowth of cells, round the former there is none. But the study of the meroblastic Teleost egg has already shown us that the part of the ingrowth which, according to the Balfour-Rauber theory, belongs to the blastoderm edge in the Amniota, became a rudimentary organ in the fishes. There is no more natural supposition than that it went a step farther and was altogether lost, or became still more reduced in size in the Amniota. The disappearance of a rudimentary organ is one of the commonest inferences in the study of the comparative anatomy of adults, and of course must occur in embryos as well. It is therefore a very different assumption from that of the occurrence of an embryonic hernia or a new and complicated embryonic form. Assuming that the mesodermic ingrowth has been lost round the blastoderm edge in Amniota, the only objection to the Balfour-Rauber theory falls to the ground, for of course this theory as well as the other is capable of explaining the existence of what Hertwig calls "unpaired mesoblast" behind the primitive streak.

It must be remembered, moreover, that the exact nature of the blastoderm edge in

Sauropsida is not well known, and that it is quite possible that further study may show the presence of a peripheral ingrowth in these embryos. Indeed Kollmann's figures (30) of sections through young chick blastoderms almost prove the existence of such an ingrowth. The later history of the blastoderm edge is extremely complicated, and the morphology of the region must be studied before the complications arise. If it should turn out that there is, as Kollmann believes, an ingrowth of cells from the blastoderm edge (which becomes a source of blood cells) the homology of the blastoderm edge in Ichthyopsida and Amniota would be proved. But Kollmann's conclusion that this peripheral ingrowth, or akroblast, is a special organ (homologous with the mesenchyme cells of certain invertebrate embryos) would not hold. For the akroblast would merely represent the last stage in the course of development, which the ventral mesoderm of simple vertebrate embryos (Amphibia, Petromyzon) has undergone.

WOOD'S HOLL, *July* 22, 1890.

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COMMON REFERENCE LETTERS USED IN THE FIGURES.

a. s.	Auditory sac.
a. n.	Auditory nerve.
a. an.	Aorta anlage.
al. c.	Alimentary canal.
aor.	Aorta.
a.	Anus.
a. p.	Anterior pole of blastoderm.
a. s. t.	Anterior sensory tract.
a. m.	Anterior mass of prim. hypoblast.
bl.	Blastopore.
br. f.	Branchial fold.
br.	Brain.
b. s. o.	Branchial sense organ.
b. f.	Body fold (separating body from yolk).
b. si.	Body sinus.
bl. ed.	Blastoderm edge.
cœl.	Cœlom.
c. t.	Connective tissue (?) cells.
cer. f.	Cerebellar (?) fold.
c. c.	Canalis centralis.

COMMON REFERENCE LETTERS USED IN THE FIGURES—Continued.

c. ep. Columnar epithelium of lens invagination.
cer. Cerebellum.
con. st. Connecting strand, bwt. organs of developing lateral line.
c. p. Central periblast.
cor. p. Cortical periblast.
c. m. Caudal mass.
d. l. Dorsal lip of blastopore.
d. l. s. t. Dorso-lateral seuse tract.
d. l. m. Dorso-lateral muscle tract.
d. f. Dorsal part of embryonic fin.
d. n. r. Dorsal root of spinal nerve.
e. p. r. Early periblastic ridge.
ep. s. Epidermic stratum.
e. e. s. Edge of embryonic shield.
ec. Ectoderm.
e. m. Egg membrane.
en. mes. Layer of cells which posteriorly becomes entoderm, anteriorly mesoderm.
en. Entoderm.
f. gr. Fin groove.
g. s. Gill slit.
g. r. Germ ring.
h. Heart.
h. e. Head end of embryo.
Iter. Iter a tertio ad quartum Ven.
k. v. Kupffer's vesicle.
l. en. Lateral entoderm.
ln. Lens.
l. l. Lateral line anlage.
l. l. o.[1] 1st organ of lateral line.
l. l. o.[2] 2d organ of lateral line.
l. l. o.[3] 3rd organ of lateral line.
l. l. o.[4] 4th organ of lateral line.
l. Liver.
l. f. Lens fibers.
l. ep. Lens epithelium.
med. Medulla.
m. con. Constriction separating medulla from mid-brain.
m. br. Mid-brain.
m. b. Muscle band (?) of cœlom wall.
m. c. Marginal blastoderm cell.
m. ep. c. Marginal epidermic cell.
mes. Mesoderm.
n. str. Neurentric streak.
n. s. Nasal sac.
nc. s. Notochordal sheath.
nc. Notochord.
nr. ch. Neural chord.
n. f. Neural furrow.
op. s. Optic sac.
op. l. Optic lobes.
oes. Œsophagus.
o. g. Oil globule.
o. g. p. Protoplasmic cap of oil globule.
p. Periblast.
p. pl. Periblast plug—Dotterpropf.
p. a. g. Postanal gut.
p. c. Pigment cell.
pec. f. Pectoral fin.
p. w. Periblast wall.
p. p. Posterior pole of blastoderm.
pr. h. Primitive hypoblast.
pr. str. Primitive streak.
ret. l. Retinal layer of optic cup.
s. f. Sensory furrow—Common anlage for ear, lateral line, and branchial sense organ.
sec. c. m. Secondary caudal mass (remnant of extra-embryonic germ ring).
som. Somites or somite mesoderm.
sp. c. Spinal cord.
s. n. r. Subnotochordal rod.
s. c. Segmentation cavity.
s. g. c. Subgerminal cavity (late stage of segmentation cavity).
t. f. Tail furrow.
un. mes. Undivided mesoderm in tail.
v. l. Ventral lip of blastopore.
v. l. m. Ventro-lateral muscle tract.
v. f. Ventral part of embryonic fin.
v. n. r. Ventral root of spiual nerve.
v. mes. Ventral mesoderm (non-embryonic part of germ ring).
w. d. Wolffian duct.
w. c. Wandering cell.
y. Yolk.
1 d. 1st cleavage plane.
2d. 2d cleavage plane.
3d. 3d cleavage plane.
4d. 4th cleavage plane.
3 ven. Third ventricle.
4 ven. Fourth veneticle.

The several series of sections are numbered from behind forwards. Objectives and oculars referred to are Zeiss's.

EXPLANATION OF PLATES.

PLATE LXXXVIII.

Fig. 1. Section through oil globule of segmenting egg.
Fig. 2. Surface view of a segmenting egg, two blastomeres in which nuclear division has already taken place.
Fig. 3. View from below of 8-blastomere stage.
Fig. 4. Irregular 8-blastomere stage.
Fig. 5. 8-blastomere stage of mackerel, radial division.
Fig. 6. Blastoderm showing cellular division, 8 into 16.
Fig. 7. 16 into 32 cells; opposite cells divide at same time.
Fig. 8. Blastoderm showing normal cleavage, 16 into 32.
Fig. 9. Stage of 16 into 32, variation.

PLATE LXXXIX.

Fig. 10. Stage of 16 into 32—variation.
Fig. 11. Resting blastoderm of 32 cells.
Fig. 12. Blastoderm—32 into 64.
Fig. 13. Section through center of 4-blastomere stage.
Fig. 14. Stage of 8 cells—section is through *a* of Fig. 3.
Fig. 15. Stage of 8 cells—section is through *b* of Fig. 3.
Fig. 16. Stage of 16 into 32 cells—section lies through *a* to *b* of Fig. 8.

PLATE XC.

Fig. 17. Stage of 16 into 32 cells—section is through *c* to *d* of Fig. 8.
Fig. 18. Stage of 32 cells—lower cells just beginning to divide—through *a–b* of woodcut, Fig. 1, Pl. 9.
Fig. 19. 32 into 64 cells—through *d–f* of woodcut, Fig. 1.
Fig. 20. Section through late segmentation stage.
Fig. 21. Surface view of edge of blastoderm of 4.40 hours—marginal cells still distinct.
Fig. 22. Surface view of blastoderm edge—7.30 hours—marginal cells not marked off from the periblast.
Fig. 23. Surface view of blastoderm edge—8.30 hours—outlines of marginal cells entirely lost.
Fig. 24. Surface view of blastoderm edge—9.30 hours—multiplication of periblastic nuclei.

PLATE XCI.

Fig. 25. Section through blastoderm of about same stage as Fig. 22. D. 4.
Fig. 26. Section through a blastoderm such as Fig. 23. D. 4.
Fig. 27. Section through periblastic wall (about same stage as Fig. 24). D. 4.
Fig. 28. Section through periblastic wall (about same stage as Fig. 24). D. 4.
Fig. 29. Section through blastoderm (9.30 hours) of about same stage as Figs. 24, 27, 28. A. 4.
Fig. 30. Section through blastoderm of 14 hours. A. 4.
Fig. 31. Section through blastoderm of 16 hours. A. 4.
Fig. 32. Surface view of blastoderm (16 hours) in which the "randwulst" is just marked out at embryonic pole—first stage in formation of germ ring. A. 4.

PLATE XCII.

Fig. 33. Surface view of blastoderm (17 hours)—germ ring formed all round blastoderm edge. A. 4.
Fig. 34. Surface view of blastoderm (20 hours)—h. e.=head end of embryonic anlage. A. 4.
Fig. 35. Side view of embryo (20 hours). A. 4.
Fig. 36. Side view of embryo (25 hours). A. 4.
Fig. 37. Embryo of 25 hours—from above. A. 4.
Fig. 38. Embryo of 31 hours—from the side. A. 4.

PLATE XCIII.

Fig. 39. Tail end and blastopore of embryo, 31 hours. A. 4.
Fig. 40. Antero-posterior section through the posterior pole of Fig. 32, $m-m'=$ apical cells of the randwulst. F. 4.
Fig. 41. Antero-posterior section through a blastoderm just a little older than Fig. 32—to show ingrowth of germ ring (*pr. h.*) at embryonic pole. D. 4.
Fig. 42. Antero-posterior section through a stage such as Fig. 33. A. 4.
Fig. 43. Longitudinal section through posterior pole of a blastoderm between Figs. 33 and 34. F. 4.
Fig. 44. Longitudinal section through posterior pole of a blastoderm of 20 hours. F. 4.

PLATE XCIV.

Fig. 45. Part of longitudinal section through posterior pole of blastoderm of about same stage as Fig. 41—unusual involution of epidermic cells. F. 4.
Fig. 46. Long section through anterior pole of same stage as Fig. 43. *v. mes*, extra-embryonic part of germ ring (homologous with ventral mesoblast of Amphibia). F. 4.
Fig. 47. Transverse section through *a–b* of Fig. 33.
Fig. 48. Longitudinal section through anterior pole of same blastoderm as Fig. 44.
Fig. 49. Transverse section through posterior pole of Mackerel blastoderm (27 hours)—intermediate between Bass blastoderms given in Figs. 35 and 36. D. 4.
Fig. 50. Part of transverse section through embryonic shield of Mackerel blastoderm, 27 hours.
Fig. 51. Section through extra-embryonic germ ring (*v. mes.*) of Mackerel, 27 hours—blastoderm half round yolk. D. 4.
Fig. 52. Longitudinal section to one side of median line of Mackerel blastoderm, 29 hours. C. 4.
Fig. 53. Trans. section through anterior part of embryonic shield of Mackerel blastoderm, 30 hours—just a little less advanced than Fig. 36.

PLATE XCV.

Fig. 54. Transverse section through posterior pole of embryonic shield of Mackerel, 30 hours. (Same embryo as Fig. 53.)
Fig. 55. Median longitudinal section of embryo, 25 hours. C. 4.
Figs. 56 (one-twelfth immersion), 57 (D. 4), 58 (D. 4). Transverse section through embryo, 25 hours. (Letters refer to objectives.)
Fig. 59. Median longitudinal section through embryo, 29 hours. D. 4.
Figs. 60, 61, 62. Transverse sections through embryo, 29 hours. D. 4.

PLATE XCVI.

Figs. 63, 64 (same series as 60–62). Transverse sections through embryo, 29 hours. D. 4.
Fig. 65. Median longitudinal section through posterior end of embryo, 33 hours. D. 4.
Figs. 66 (D) 67 (D), 68 (F), 69 (D), 70 (F). Series of transverse sections through embryo of 35 hours. (Letters refer to objectives.)

PLATE XCVII.

Figs. 71 (D), 72 (D) (same series as Figs. 66–70). Series of transverse sections through embryo of 35 hours.

Figs. 73 (D), 74 (F), 75 (D), 76 (F), 77 (F), 78 (D), 79 (D). Series of transverse sections through embryo of 39 hours.

Fig. 80. Transverse section through optic sac of embryo, 39 hours. D. 4.

Fig. 81. Ectoderm of embryo, 39 hours. F. 4.

PLATE XCVIII.

Fig. 82. Transverse section through embryo, 41 hours, in region of Kupffer's vesicle. D. 4.

Fig. 83. Median longitudinal section through head end of embryo, 45 hours. C. 4.

Fig. 84. Median longitudinal section through tail end of embryo, 45 hours. D. 4.

Fig. 85. Longitudinal section to one side of median line through embryo, 45 hours. C. 4.

Fig. 86. One of posterior somites of Fig. 85. F. 4.

Fig. 87. One of anterior somites of Fig. 85. F. 4.

Figs. 88 (D), 90 (D), 91 (F). Series of transverse sections through embryo of 45 hours.

Fig. 89. Transverse section through region of Kupffer's vesicle of embryo slightly more advanced than Fig. 88. D. 4.

PLATE XCIX.

Figs. 92 (F), 93 (F), 94 (D), 95 (D), 96 (D), 97 (D), from same series as Figs. 88–91. Transverse sections through embryo, 45 hours. D. 4.

Fig. 98. Surface view of tail end of embryo, from below, 49½ hours.—*t. f.* (tail fold), marks line along which the ectoderm covering the tail bends round over the yolk. D. 4.

Figs. 99 (D), 100 (D). Transverse sections through embryo of 49½ hours.

PLATE C.

Figs. 101 (D), 102 (D), 103 (F), 104 (F), 105 (D), 106 (D), 107 (F), 108 (D), from same series as Figs. 99 and 100. Series of transverse sections through embryo of 49½ hours.

Fig. 109. Transverse section through tail end of embryo, 53 hours. D. 4.

PLATE CI.

Fig. 110. Transverse section through trunk of embryo, 53 hours. F. 4.

Fig. 111. Transverse section through tail of embryo, 59 hours. D. 4.

Fig. 112. Ventral portion of a section similar to Fig. 111. F. 4.

Figs. 113 (D), 114 (D), 115 (D), 116 (F). Series of transverse sections through embryo of 59 hours.

PLATE CII.

Fig. 117 (D), belongs to same series as Figs. 113—118, through embryo of 59 hours.

Fig. 118. Transverse section through eye of embryo, 59 hours. D. 4.

Fig. 119. Transverse section through tail of embryo, 65 hours. D. 4.

Fig. 120. Transverse section through 1st organ of lateral line, 65 hours. F. 4.

Figs. 121, 122. Transverse sections through connecting strand of lateral line of 65-hour stage. F. 4.

Fig. 123. Transverse section through cerebellar (?) folds and dorso-lateral sense tract of embryo, 65 hours. D. 4.

Fig. 124. Transverse section through eyes and infundibulum of 65-hour stage. D. 4.

Fig. 126. Transverse section through posterior trunk of embryo, 75 hours. D. 4.

PLATE CIII.

Figs. 126^{i}, 126^{ii}, 126^{iii}, 126^{iv}. Series of sections through postanal lateral line of embryo, 75 hours. F. 4.

Figs. 127 (D), 128 (D), 129 (D), 130 (D)—Fig. 126 belongs to this series. Series of transverse sections through embryo, 75 hours.

PLATE CIV.

Figs. 131 (D), 132 (F), 133 (D), 134 (D), 135 (C) from same series as Figs. 126–130. Series of transverse sections through embryo, 75 hours.

Fig. 136. Transverse section through region of pectoral fins of larva, 86 hours. D. 4.

Fig. 137. Four muscle fibers of Fig. 136.

Fig. 138. Part of transverse section through larva, 100 hours, to show origin of liver, *l*. D. 4.

PLATE CV.

Fig. 139. Transverse section through pectoral fins of larva, 112 hours. C. 4.

Fig. 140. Part of transverse section through region of liver in larva of 112 hours. D. 4.

Fig. 141. Transverse section through larva of 136 hours—region of liver. C. 4.

Fig. 142. Three muscle fibers from Fig. 141.

Figs. 143 (C), 144 (D), 145 (D). Transverse sections through larva of 160 hours—region of yolk and liver.

PLATE CVI.

Fig. 146. Surface view from above of embryo 33 hours. C. 4.

Fig. 147. Surface view from above of part of embryo 37 hours. D. 4.

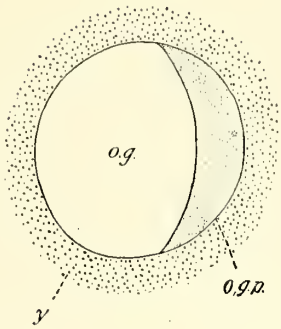
Fig. 148. Surface view from above of embryo 45 hours. C. 4.

PLATE CVII.

Fig. 149. Surface view from below of embryo, 62 hours. C. 4.

Fig. 150. Surface view from above of embryo, 65 hours. C. 4. b–f = fold which constricts body from yolk.

Fig. 151. Side view of embryo, 65 hours. A. 4.



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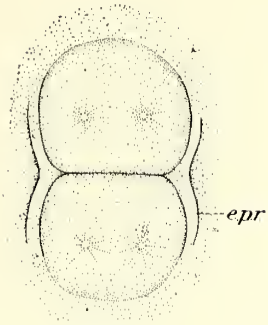

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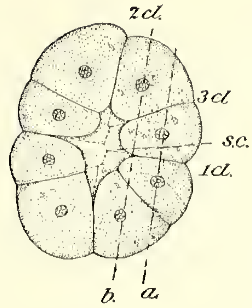

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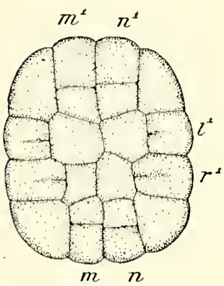

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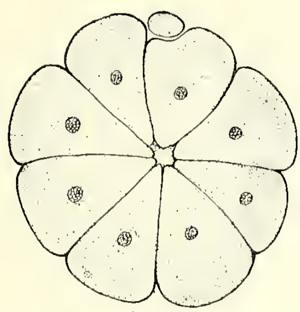

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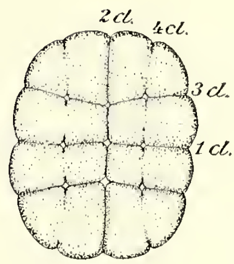

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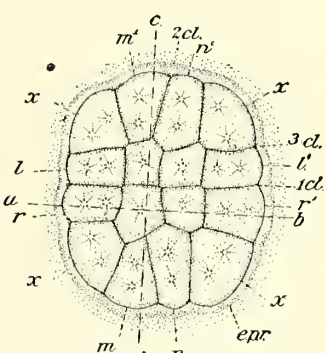

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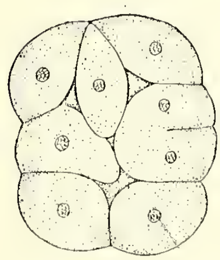

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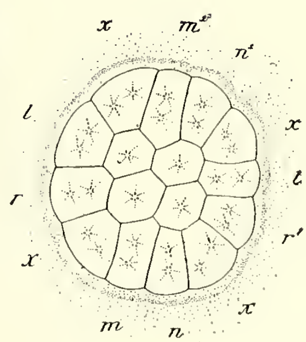

Fig. 9

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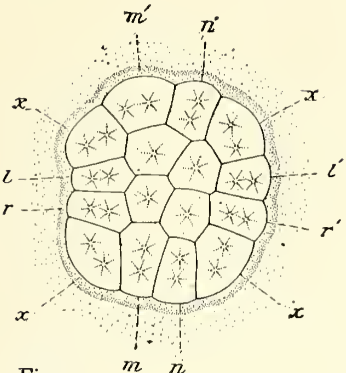

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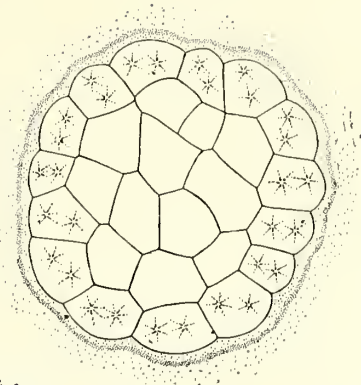

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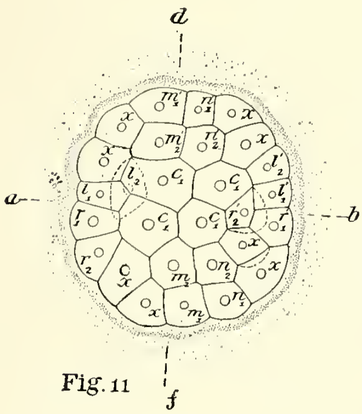

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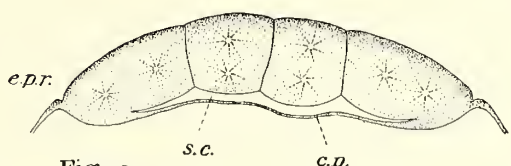

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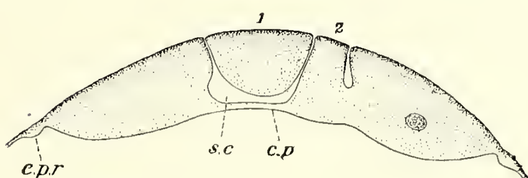

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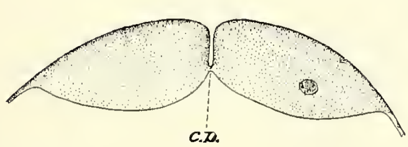

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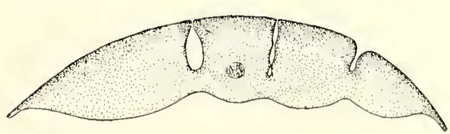

Fig. 14

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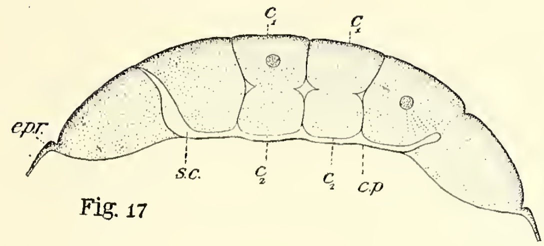

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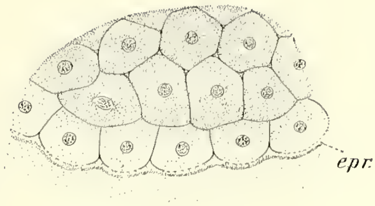

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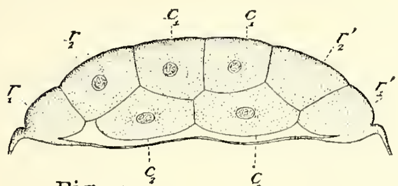

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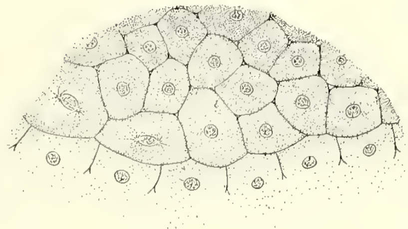

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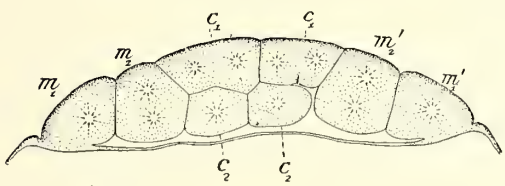

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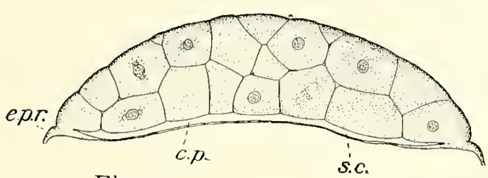

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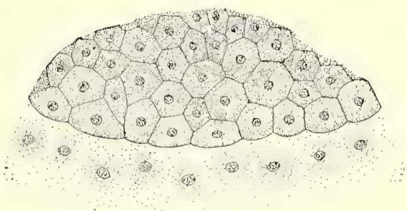

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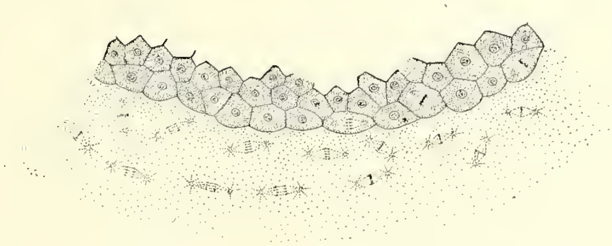

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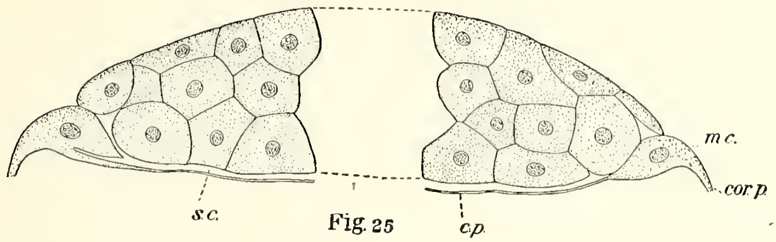

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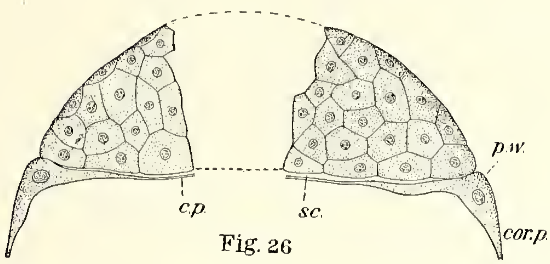

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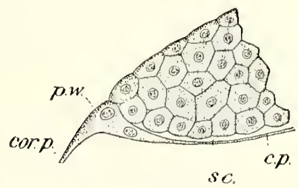

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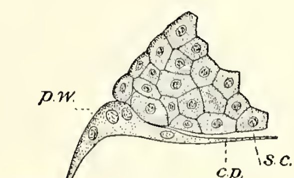

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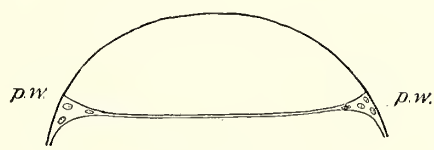

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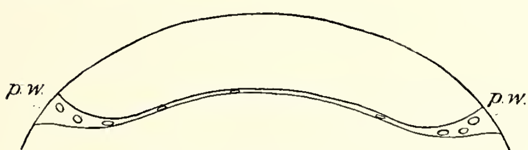

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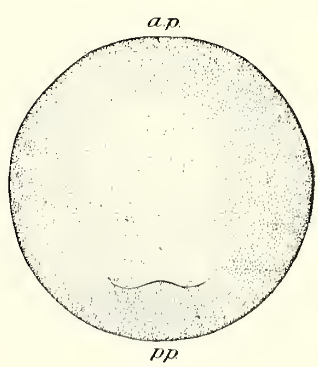

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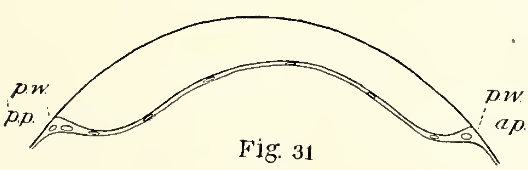

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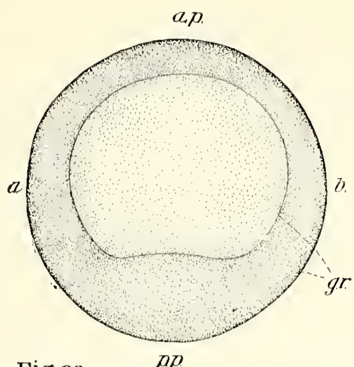

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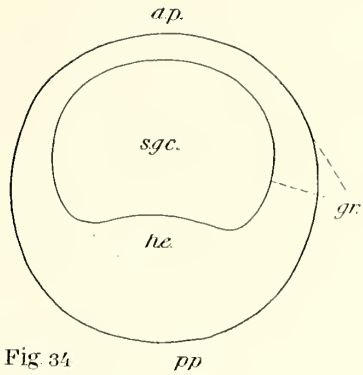

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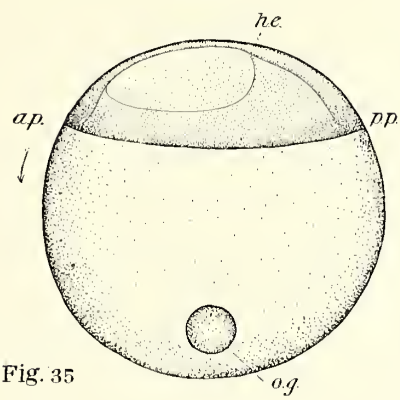

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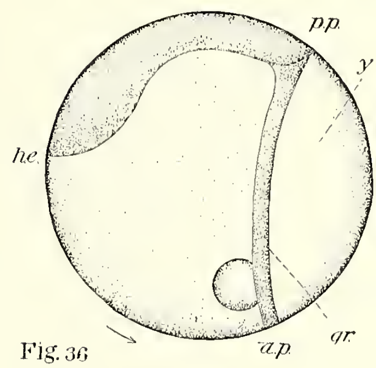

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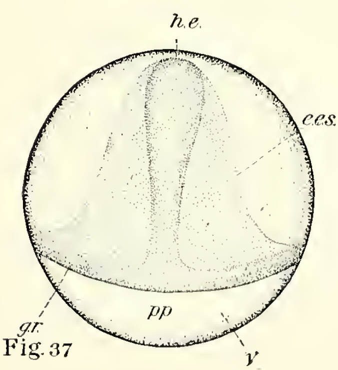

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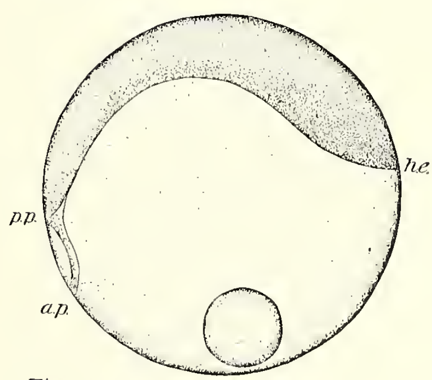

Fig. 38

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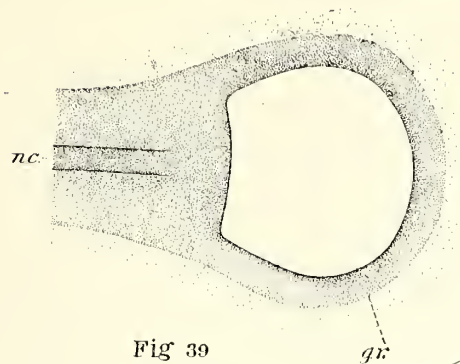

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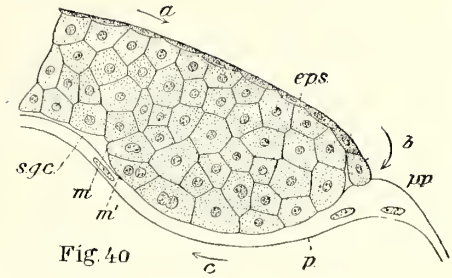

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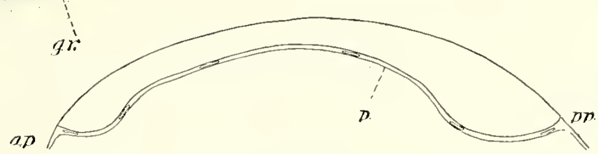
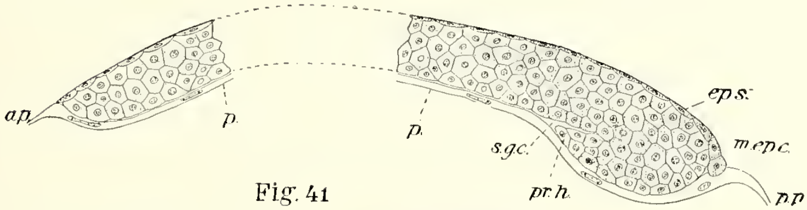


Fig. 42



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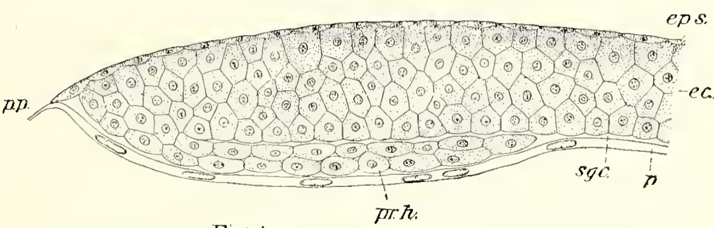

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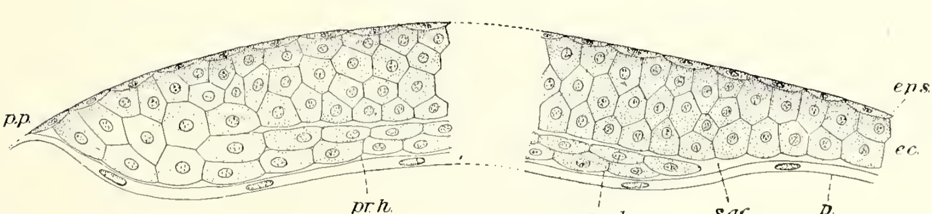

Fig. 44

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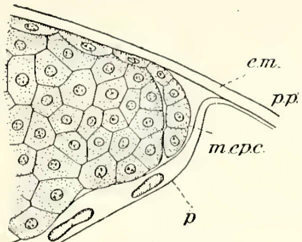

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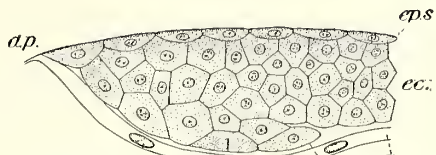

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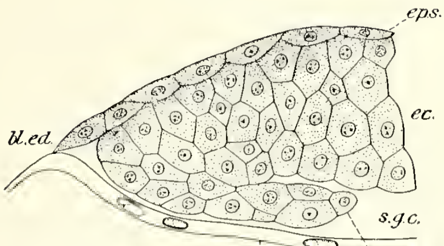
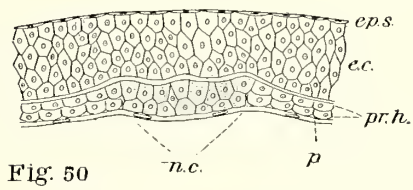


Fig. 47



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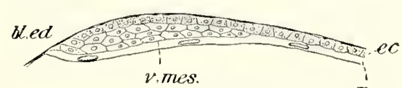

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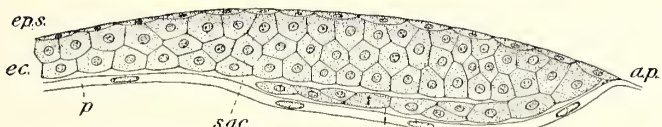

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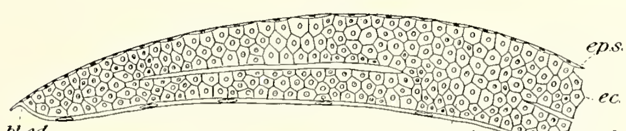

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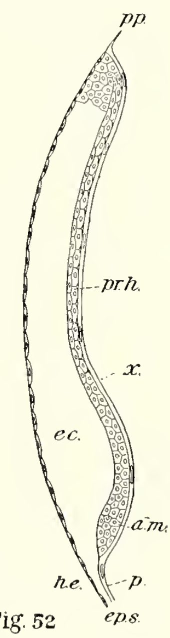

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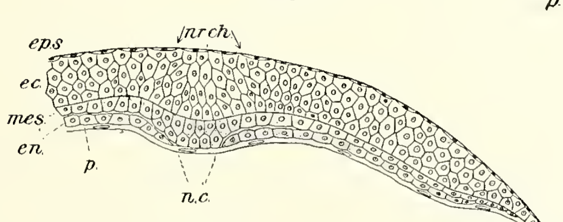

Fig. 53

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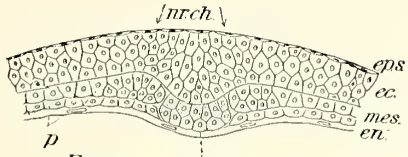

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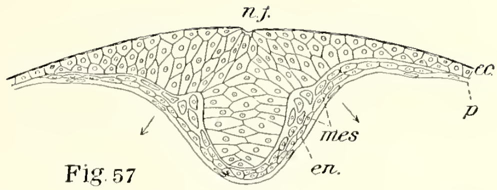

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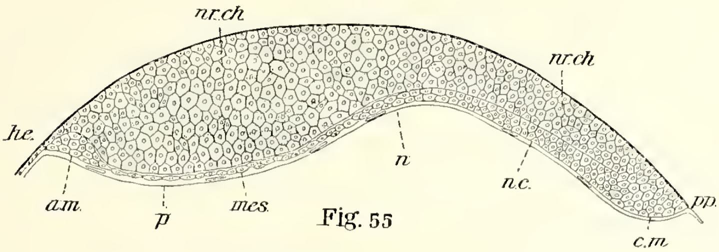

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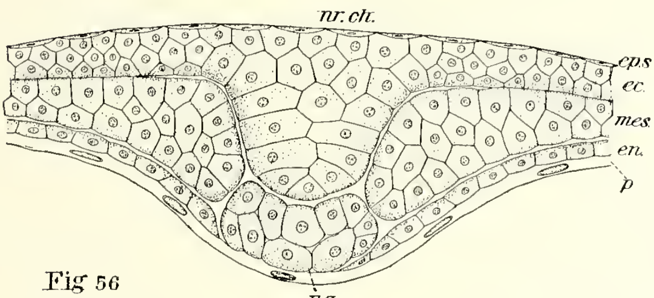

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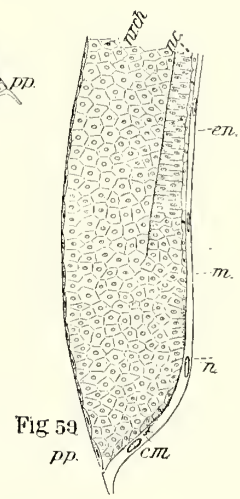
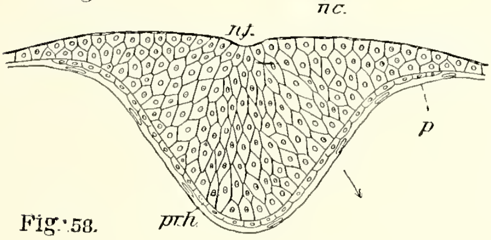


Fig 59



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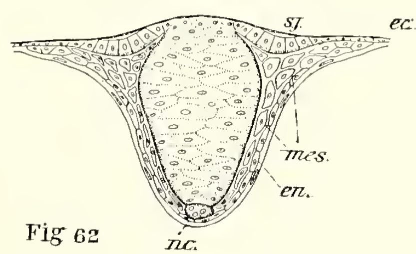

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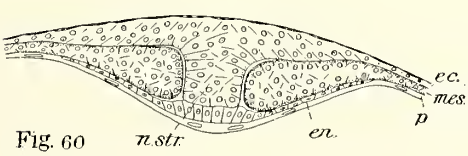

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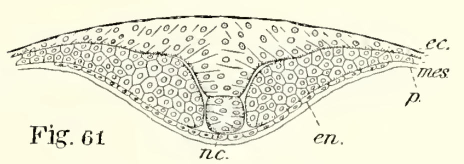
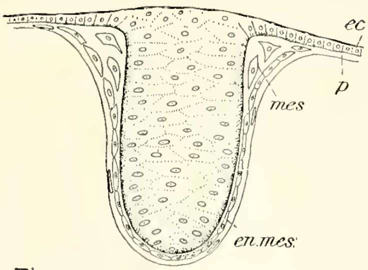


Fig. 61

H.V.W. Del.



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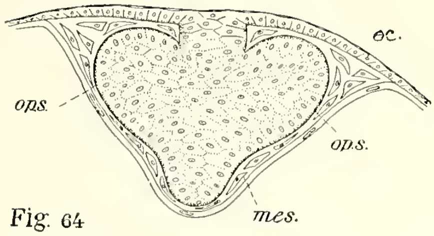

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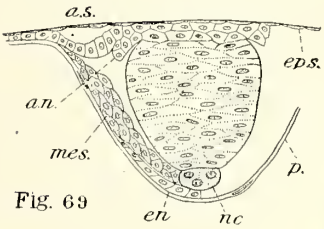

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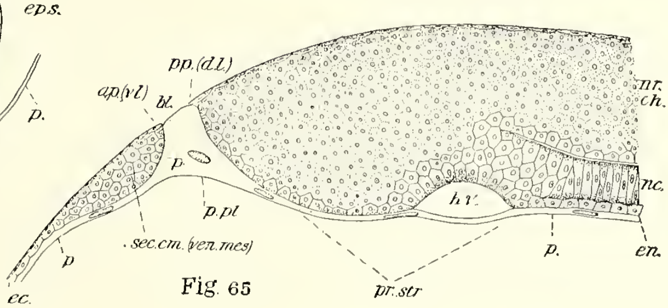

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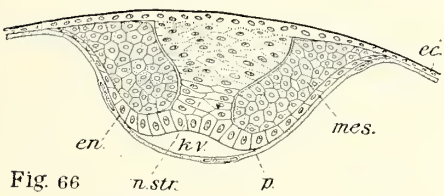

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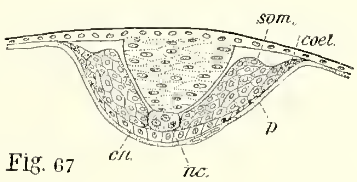

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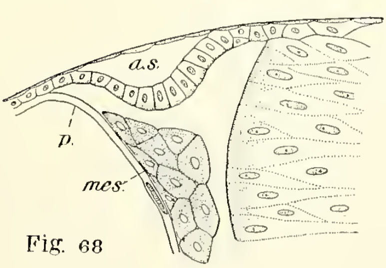

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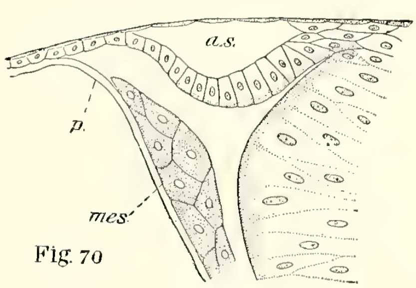

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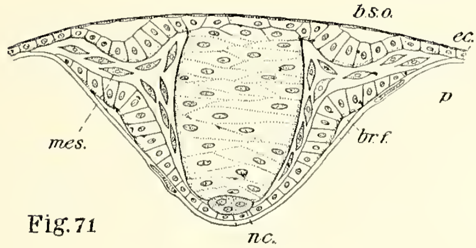

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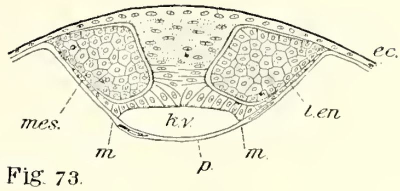

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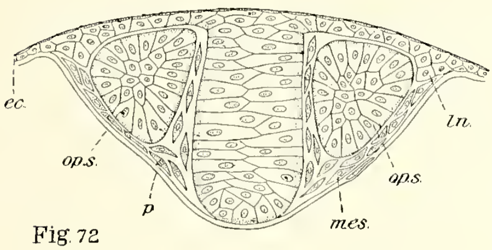

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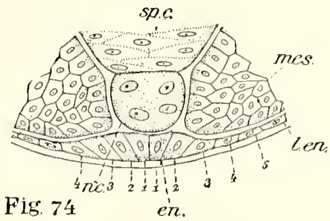

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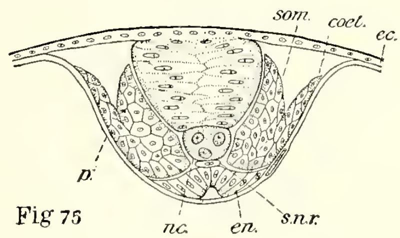

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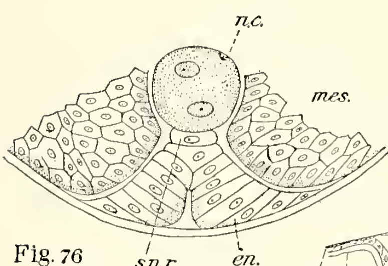

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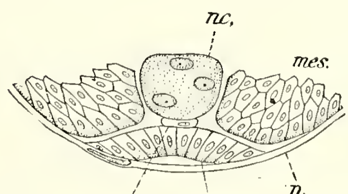

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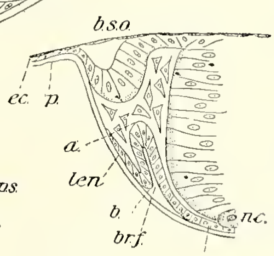
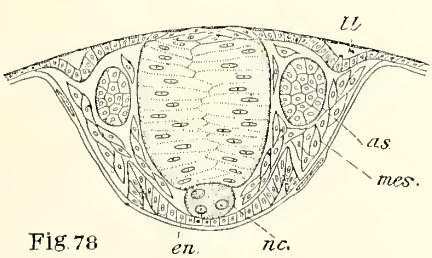


Fig. 79

Fig. 81



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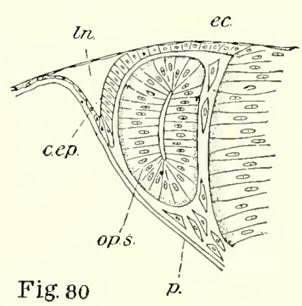
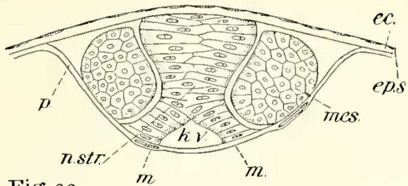


Fig. 80

H.V.W. DEL.



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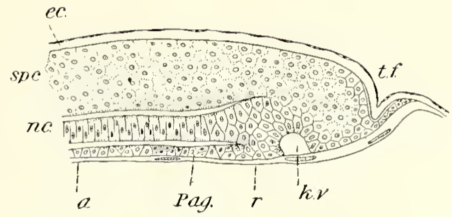

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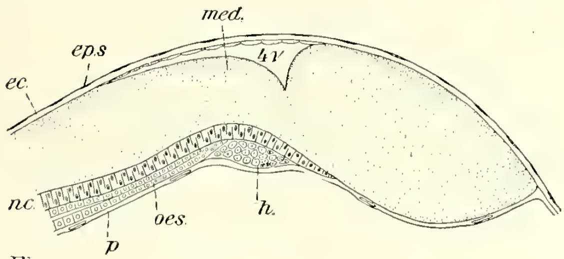

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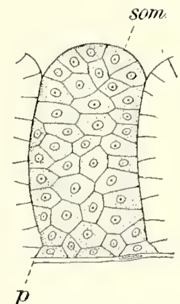

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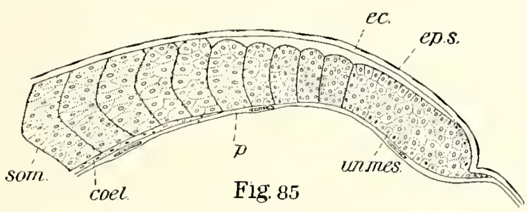

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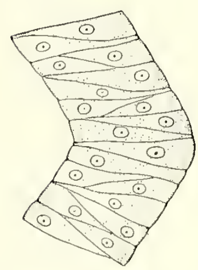
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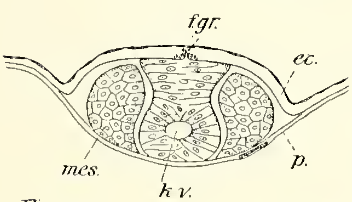

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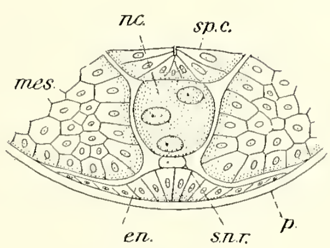

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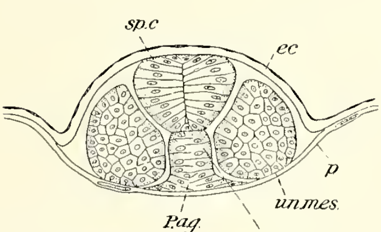

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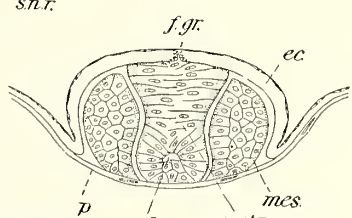

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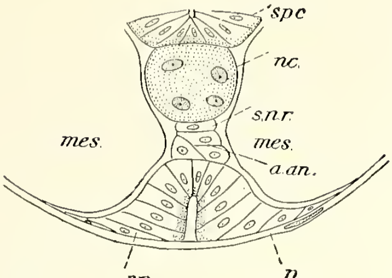
H.V.W. DEL.



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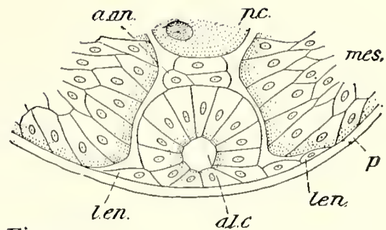

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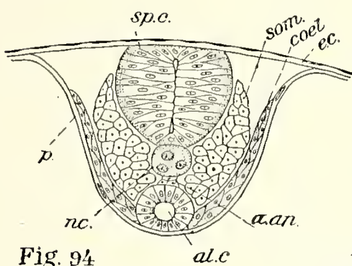

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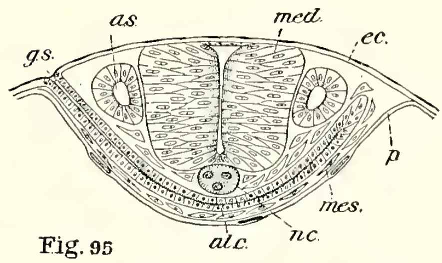

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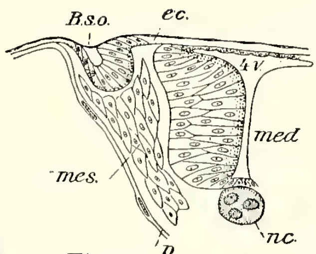

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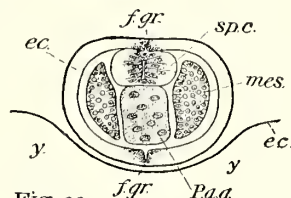

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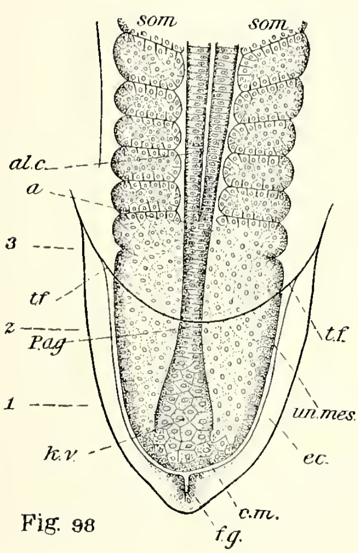

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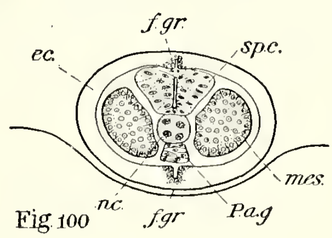

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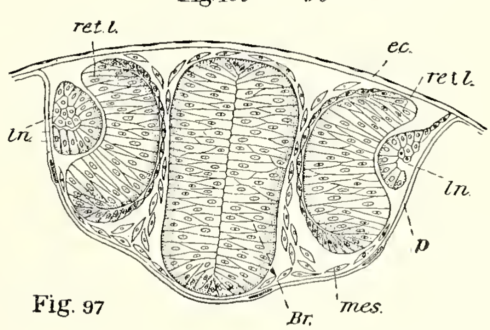
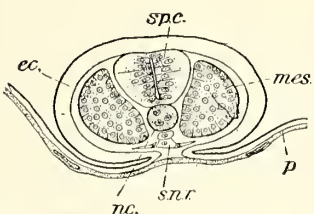


Fig. 97

H.V.W. DEL.



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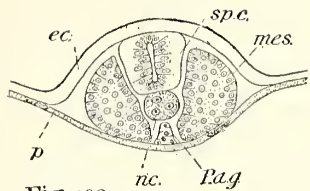

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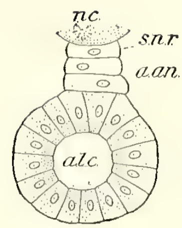

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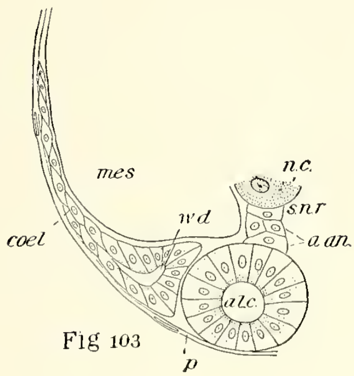

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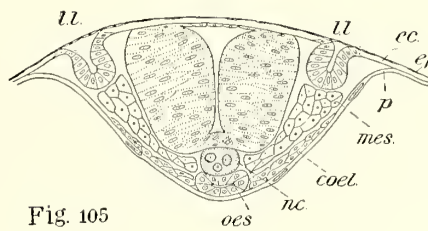

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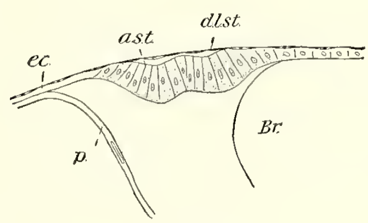

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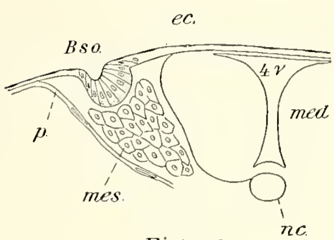

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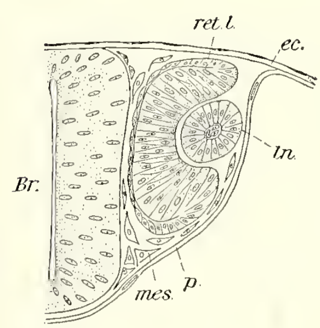

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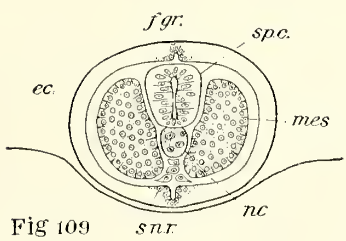

Fig 109

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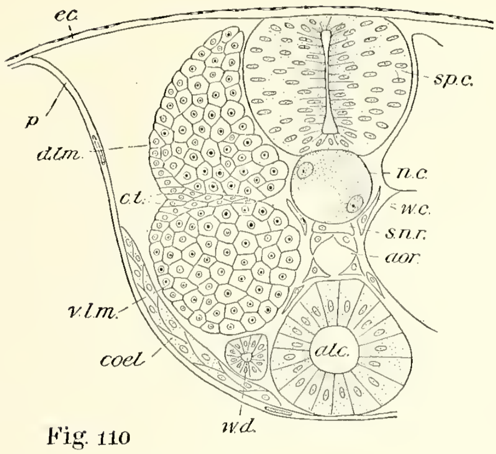

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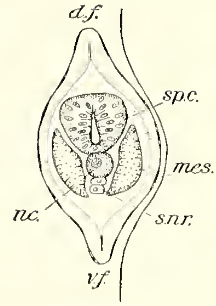

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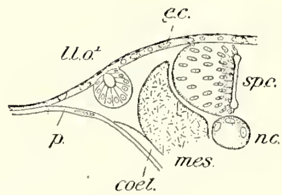

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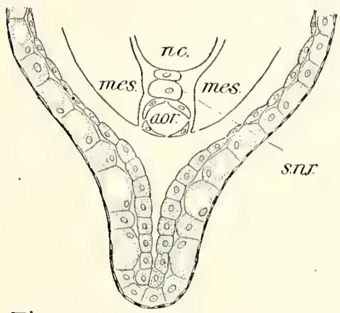

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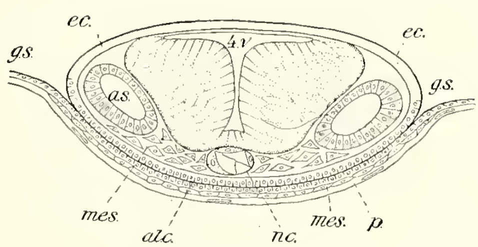

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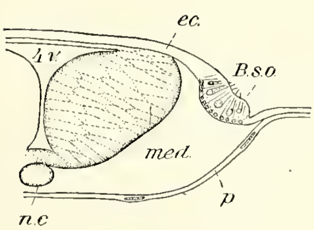

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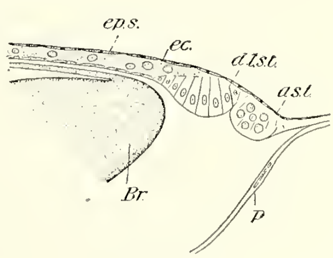

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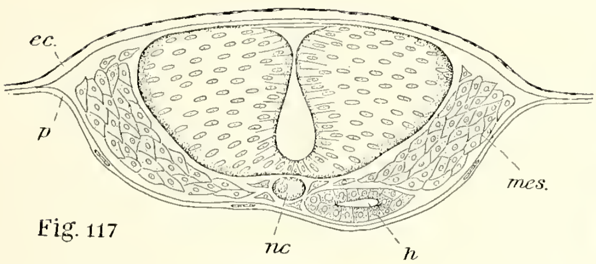

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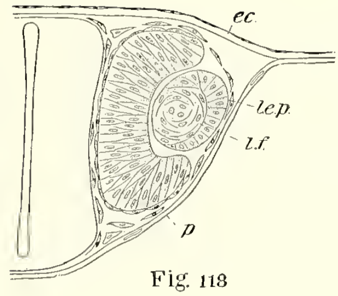

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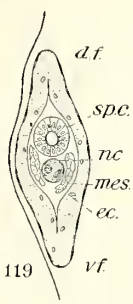

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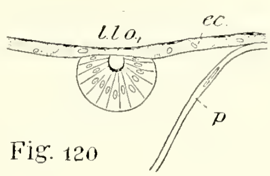

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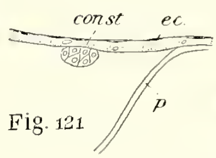


Fig. 121

Fig. 122

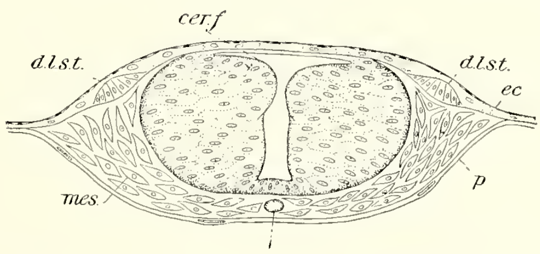


Fig. 123

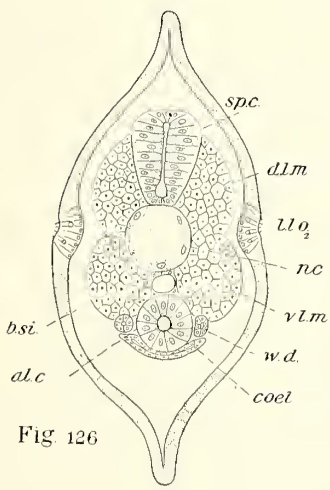


Fig. 126

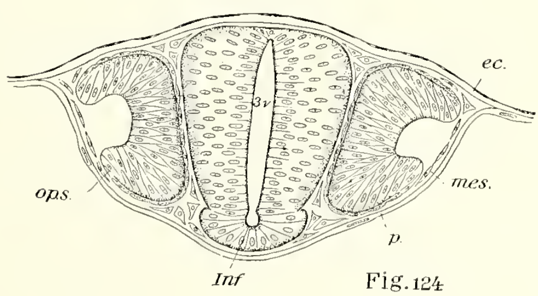
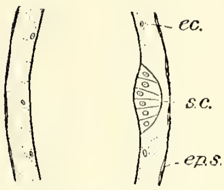


Fig. 124

H.V.W. DEL.



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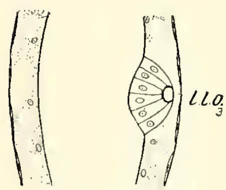

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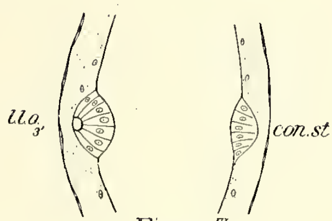

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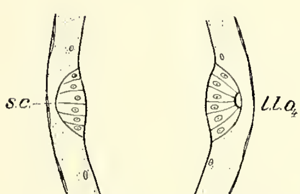


Fig. 126^iv

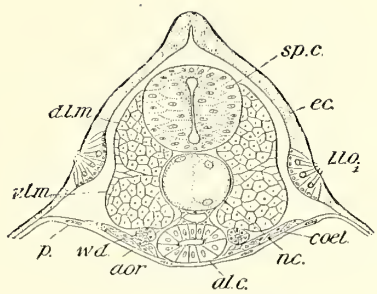


Fig. 127

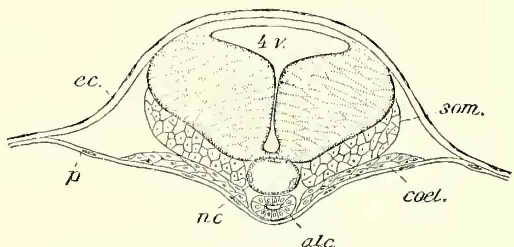
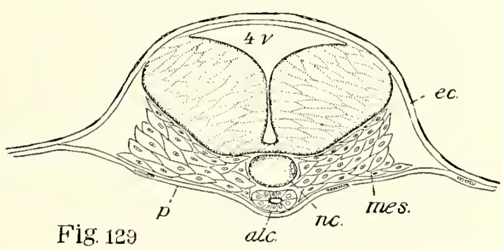


Fig. 128



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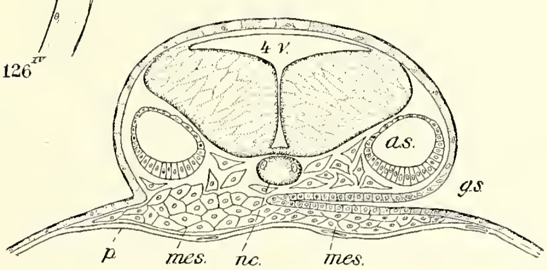

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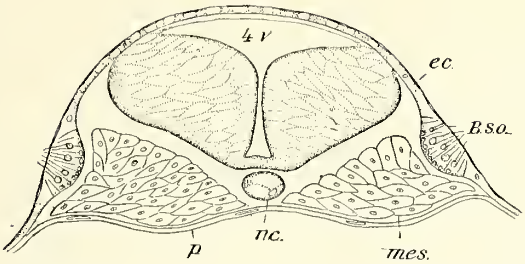
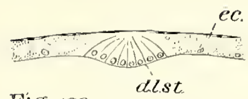


Fig 131



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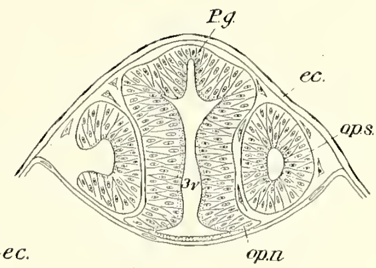

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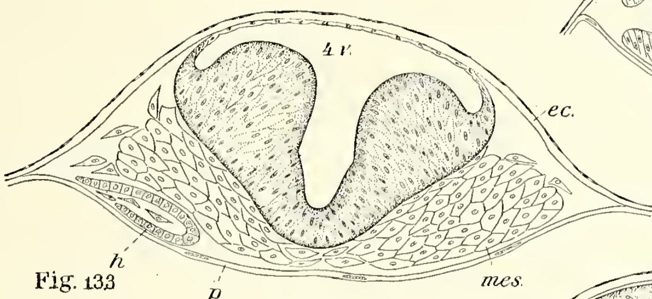

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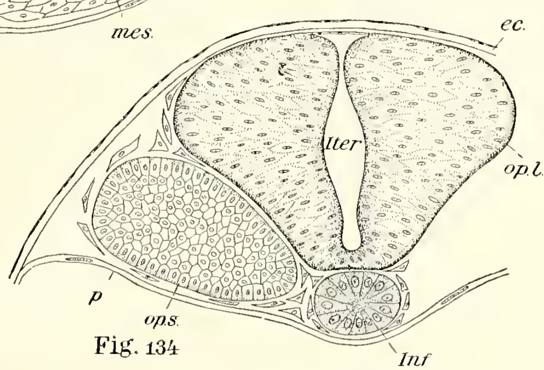

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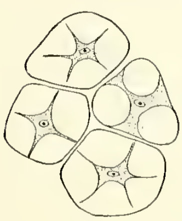


Fig. 137

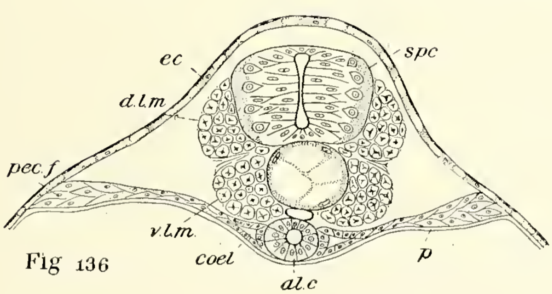


Fig 136

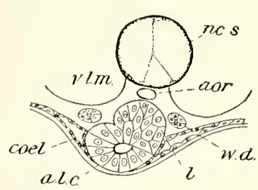


Fig. 138

H.V.W. Del.

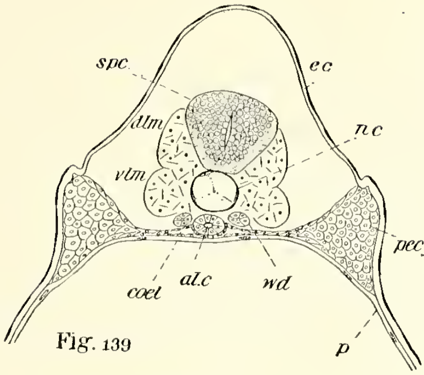
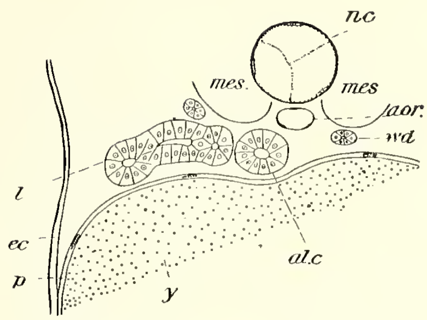


Fig. 139



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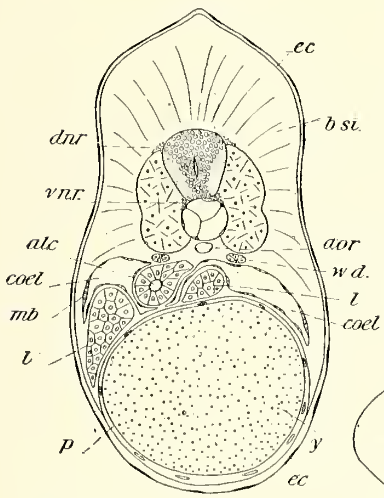

Fig. 141

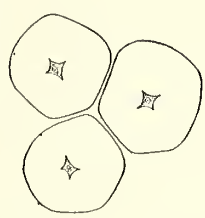
Fig. 142

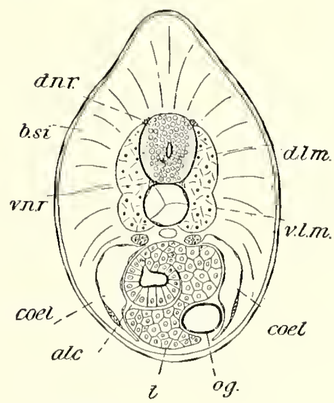

Fig. 143

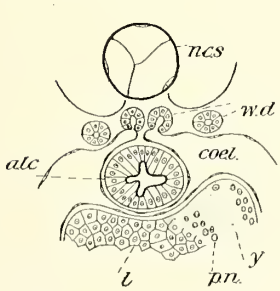

Fig. 144

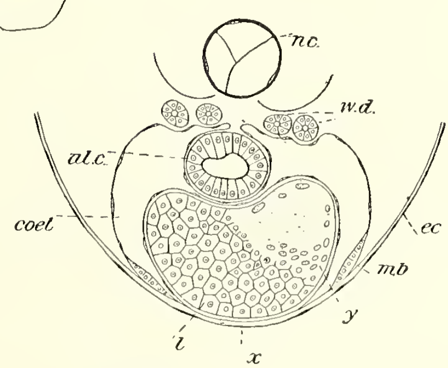

Fig. 145

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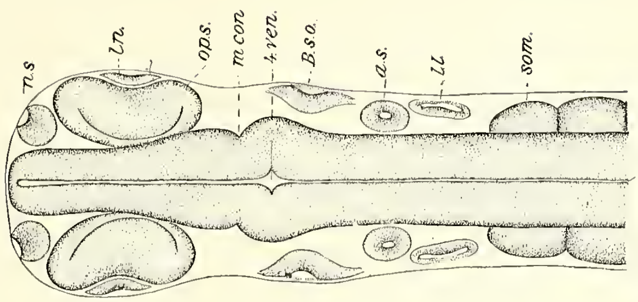


Fig. 148

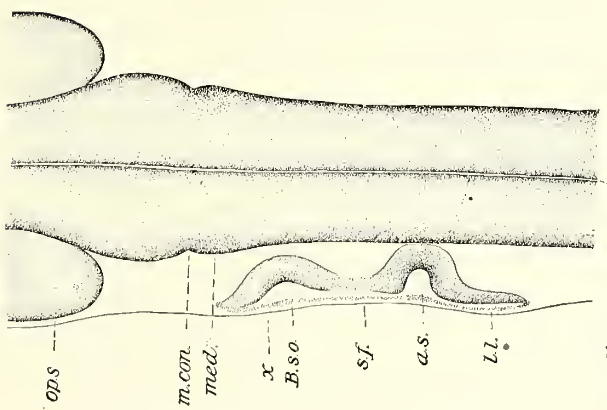


Fig. 147

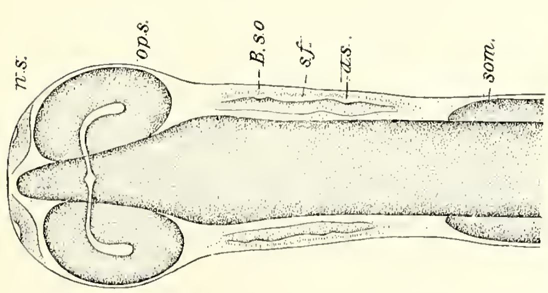


Fig. 146

H.V.W. DEL.

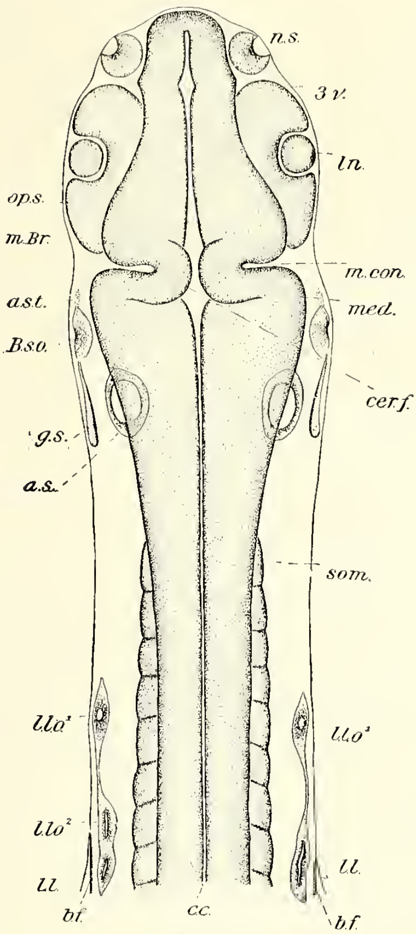


Fig. 150

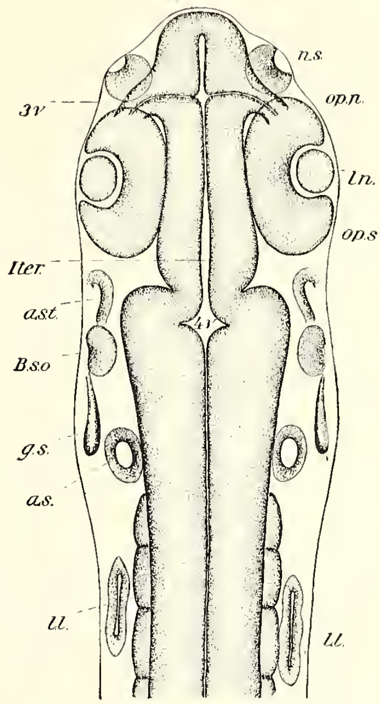


Fig. 149

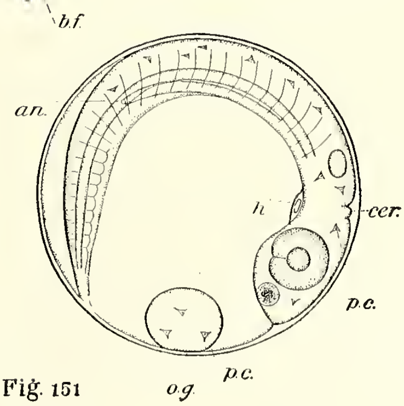


Fig. 151

H.V.W. DEL.

14.—THE FISHING GROUNDS OF BRISTOL BAY, ALASKA: A PRELIMINARY REPORT UPON THE INVESTIGATIONS OF THE U. S. FISH COMMISSION STEAMER ALBATROSS DURING THE SUMMER OF 1890.

BY LIEUT. COMMANDER Z. L. TANNER, U. S. NAVY.

[Accompanied by three charts, forming Plates CVIII–CX.]

INTRODUCTION.

Bering Sea was designated as the working ground for the steamer *Albatross* during the summer of 1890, the object of the cruise being to develop its offshore fishing grounds. The exploration of the cod banks of Bristol Bay occupied most of the time, and this report is chiefly limited to a discussion of that region. We also made a partial reconnoissance of the coast lines as an indispensable preliminary to the fishery investigations. In prosecuting the work the region was thoroughly sounded, the currents, wind, and weather observed, and other information obtained of such direct value to the fisherman and mariner that it was deemed advisable to present the principal results in advance of the regular report. All the bearings given are magnetic, and the depths are expressed in fathoms. Longitudes depend upon Dall's astronomical station, Iliuliuk Harbor (point opposite the wharf), being in longitude 166° 31′ 44.2″ W.

Bristol Bay may be said to include all that part of Bering Sea lying east of a line drawn from the Northwest Cape of Unimak Island to the Kuskokwim River. The Island of Unimak and the Alaska Peninsula bound it on the south and east, and separate it from the Pacific Ocean. The Naknek River is at the head of deep-water navigation, while the bay itself terminates in the Kvichak River, a few miles to the northward. The region about the Nushagak River, Kulukak Bay, and the Kuskokwim forms its northwest boundary.

The shore lines are usually low, and without distinctive features, but high mountain ranges and volcanic cones extend along the central parts of Unimak and the Alaska Peninsula. These rugged snow-covered mountains and lofty peaks would serve as unmistakable landmarks were they not obscured by the almost constant fogs which prevail in that region during the summer months. In fact, they were so seldom visible during the season of 1890 that the officers of the *Albatross* made no pretense

of using them as landmarks. The shore line and objects near the sea level were often seen beneath the fog when the higher lands were obscured, and, therefore, most of the available landmarks were found on or near the beach.

THE COAST FROM UNIMAK PASS TO PORT MÖLLER.

The Northwest Cape of Unimak is low with detached rocks, around which strong tidal currents sweep. The land falls away to the eastward in a gentle curve, forming an open bay about 4 miles in depth between the cape and Cave Point, which lies NNE. ½ E., 16 miles from the former. It is a vertical rocky cliff about 150 feet in height, and takes its name from a cave on its face, inhabited by sea birds which in summer time hover about it in thousands, making it conspicuous in clear weather by their numbers and in fogs by their constant cries.

The snow-clad peak of Progrumnoi Volcano, rising to an altitude of 5,523 feet above the sea, forms a striking background to the low monotonous coast.

Passing Cape Lapin, a low bluff point 8 miles from Cave Point, the coast falls away slightly for 6 miles, when it turns abruptly to the eastward for 5 miles, and then takes a northerly direction, forming Shaw Bay. This bay is open to the northward, but affords protection from all winds to the southward of east or west. The approaches are clear, and the water shoals gradually to 6 fathoms, black sand, about three-quarters of a mile from shore.

From Shaw Bay to Isanotski Strait the coast trends in a northeasterly direction, is very low, and has several rocky patches extending from half a mile to a mile from shore, making navigation unsafe inside the 12-fathom line. The volcano of Shishaldin rises 8,953 feet, about midway between the above points and 7 or 8 miles inland. Isanotski Strait is available only for vessels of the smallest class.

From the strait to Cape Glasenap, about 19 miles, the coast line retains the same general direction and is very low until reaching the latter point, which is oval in form, about 150 feet in height, and has been called Round Point.

Izenbek Bay covers a large area at high tide, but much of it becomes dry at low water. A small vessel may, however, find a secure harbor behind the cape. The channel follows close around the point, and has a depth of 10 to 12 feet on the bar.

Amak Island is of volcanic origin, about 2½ miles in length, 1½ miles in width, and 1,682 feet in height. It lies 11 miles northwest from Cape Glasenap. The beaches are mostly of huge water-worn bowlders, having vertical bluffs from 30 to 150 feet in height with moss-covered plateaus, which in summer time are covered with a rank growth of grass and wild flowers. The central peak is of dark brown rock, exceedingly rugged and precipitous, and entirely devoid of vegetation. The southeast point was found to be in latitude 55° 25′ 05.6″ N. and longitude 163° 07′ 33.6″ W. There is foul ground off the northwest extremity of the island, several rocks awash or under water, and Sea Lion Rock lying between 2 and 3 miles distant. The latter is several hundred yards in extent and about 150 feet high, its slopes being occupied by an extensive rookery of sea lions.

The Khudiakof Islands extend about 19 miles NNE. ½ E., between Cape Glasenap and Moffett Point. They are but little above high water, and some of them are connected by narrow spits when the tide is out.

From Moffett Point the low coast trends north by east 15 miles to Gerstle Bay, then to the nor hward and eastward about 55 miles to Wolf Point, on the western side of the entrance to Port Möller.

The Khudubin Islands occupy the last 23 miles of this distance. They are very low, and it is difficult to distinguish them from the mainland, the only distinctive feature being a knob about 25 feet high on the east end of Kritskoi. The land between Herendeen Bay and Nelson Lagoon is very low.

PORT MÖLLER, HERENDEEN BAY, AND VICINITY.

Port Möller and Herendeen Bay had no commercial importance until the recent opening of a coal mine in the latter, which has drawn attention to this almost unknown region. The *Albatross* visited the mine twice during the season of 1890, and made a survey which was found to be sufficiently accurate for purposes of navigation. The chart should be used with caution, however, until it is ascertained whether the extensive banks guarding the entrance are permanent or shifting.

To enter Port Möller from the southward, pass Walrus Island in from 10 to 12 fathoms and bring Entrance Point to bear east-southeast. It will then be about 8 miles distant and have the appearance of being the southern extremity of a high and bold headland, the first that approaches the coast between that point and Cape Glasenap. Stand in, keeping the point on the above bearing until within 2 or 3 miles, when it will show as a low spit backed by a cluster of hillocks, the high land before referred to being seen farther inland. Pass Entrance Point at a distance of 1 mile, steering about SSE. ½ E., and stand for Harbor Point, passing it within a quarter of a mile, where anchorage may be found. The point is low.

A shoal makes off from Entrance Point about northwest by north, extending between 3 and 4 miles, and vessels making for the harbor from the northward are liable to run in behind it. Entrance Point should not be brought to bear to the southward of southeast after having approached within 4 miles of it.

To enter Herendeen Bay, bring Entrance Point to bear NE. ½ E., 1 mile distant, and Point Divide SSW. ⅝ W., 8¾ miles distant; then steer for the latter, keeping it on that bearing until within 2½ miles, when the course may be changed to about SW. ¾ S., passing in mid channel between Point Divide and Doe Point. The least water is 4 fathoms at the entrance to the channel.

Having cleared Hague Channel, bring Coal Bluff to bear SE. ¼ S., and stand for it until Point Divide bears S. by E. ½ E., 1½ miles distant and about 400 yards open of Doe Point; then SSE. ¾ E., until Eagle Rock is abeam, keeping the above points a little open to clear Half Tide Rock. Then steer S. by E. ¼ E. until Shingle Point is abeam, when a course may be laid for Mine Harbor, giving Bluff Point a berth of a quarter of a mile.

Mine Harbor is small but free from dangers, except Midway Reef, which shows at half tide. Anchor in from 12 to 15 fathoms, and if a vessel intends to remain any time it is advisable to moor.

It is high water in Mine Harbor, full and change, at 8 hours 0 minutes 0 seconds, rise 15 feet, and it occurs at Entrance Point about two hours earlier, with a rise of 10 to 12 feet.

Hague Channel is 1 mile in width at its northern entrance, and is contracted to

less than half a mile between Point Divide and Doe Point. The tidal streams are very strong, and near high water they sweep across the narrow channel and over the flats, making it impossible to steer a compass course. They are more regular near low tide, which is the best time to make the passage, as the channel is indicated by the flats showing above water on either hand.

Johnston Channel has from 7 to 15 fathoms of water, but is very narrow with steep sides. It is difficult to find but, once in, the navigation is comparatively simple, as the tides follow the general direction of deep water. The width of the northern entrance is a quarter of a mile, with little variation until near the south extremity, where it contracts to 250 yards. Having cleared the channel and entered the upper bay, there is ample room and depth of water in every direction, Crow Reef being the only outlying danger.

Anchorages may be found anywhere between Walrus Island and Entrance Point in case of fog, and a vessel may anchor in Hague Channel, but the tides are strong. There are fairly good anchorages under the north side of Point Divide and Doe Point where, near the bank, a vessel will be out of the strength of the current. The *Albatross* anchored in mid-channel a mile inside of the above points at the time of spring tides, and the flood came in with a bore between 2 and 3 feet in height, the patent log registering a 9-knot current for some time, with a swell which occasionally splashed into the scuppers. There is fair anchorage off the northern entrance to Johnston Channel, and an excellent one at its southern extremity, off Marble Point, or, in fact, almost anywhere in the upper bay. The last quarter of the flood tide is the best time to pass through this channel.

High land rises at the base of Harbor Point, and extends to the northward and eastward near the center of the peninsula. Point Divide is 50 feet in height, and mountain ranges rise a few miles back. The coal measures are found between Mine Harbor and the head of Port Möller. Doe Point is 40 feet in height, while the rest of Deer Island and the mainland south and west of it is generally lower. The southern shores of Herendeen Bay are mountainous with intervening valleys, the whole face of the country being covered with rank grass and wild flowers during the summer months; but there is no timber except occasional small poplars, alder bushes, and willows. Fresh winds with fog and mist blow across the low divides from the Pacific, obscuring the sun and greatly increasing the rainfall in Port Möller and vicinity.

The region is uninhabited, except by men employed at the coal mine, yet bears and reindeer were plentiful, and the waters teemed with salmon. There are no large fresh-water streams entering the bay, however, which probably accounts for the absence of Esquimaux.

The coal mine in Herendeen Bay lies 1¼ miles from the landing in Mine Harbor, the coal being transported to the water front by a steam motor over a light tramway.

The opening of this mine is an event of no little importance to vessels visiting Bering Sea, and, the *Albatross* having used between 200 and 300 tons of its first output, the following report of Passed Assistant Engineer C. R. Roelker, U. S. Navy, chief engineer of this vessel, on the results obtained by the consumption of 80 tons of this coal, will be read with more than usual interest:

The following statement regarding the coal received from the mine recently opened at Herendeen Bay is based on the results obtained wtih some 80 tons of this coal consumed while this vessel was engaged in her regular work at sea, under average conditions. The quantities of coal consumed and

of refuse matter were carefully measured, the behavior of the coal in the furnaces was closely observed, and the results obtained have been deduced from the entries in the steam log.

The average consumption of the coal was at the rate of 25 pounds per square foot of grate per hour. The boilers furnished the same amount of steam as when we have been using a fair quality of Wellington coal, but to obtain the result we had to burn from 20 to 25 per cent. more of the Herendeen Bay coal.

The coal ignites readily, and burns with considerable flame, forming a closely cohering coke which easily breaks up into small pieces; thus a considerable amount of small particles of coal is lost through the grates. There was a large proportion of fine stuff in the coal, which burned well, but contained an excessive quantity of refuse matter. The refuse amounted to 26 per cent. of the total weight of fuel consumed; it consists of ash and cinders, no glassy clinkers being formed. The smoke produced is lighter in color than that of Wellington coal, and less soot is formed.

To form a correct estimate of the value of this coal for steaming purposes from the foregoing statement, the following facts should be taken into consideration, viz: The coal received by us was the first lot taken from this newly opened mine. It came from one of the smaller veins, through which a tunnel had been driven then a distance of about 200 feet, in order to get access to the main veins. No proper facilities for screening the coal existed, and in order to supply the quantity required by us a large amount of fine coal containing much dirt was delivered. It may be reasonably expected that, as the mine becomes further developed and proper screening facilities are provided, the amount of refuse matter in the coal will be greatly diminished and its steam-generating power correspondingly increased. It will be absolutely necessary, however, to store this coal under shelter, as it appears to absorb moisture readily, and the constant rains which have prevailed in this region during the present season would soon saturate it to such an extent as to greatly diminish its value as fuel.

THE COAST FROM PORT MÖLLER TO THE KUSKOKWIM RIVER.

The coast is low for 19 miles between Entrance Point and Cape Kutuzof, which rises in a rounded bluff to an elevation of 150 feet.

Cape Seniavin, 11 miles to the northward and eastward, is a rocky point 75 feet high. Passing it, the low monotonous beach continues to the Seal Islands; a cluster of small hillocks near the beach, 12 miles from Cape Seniavin, being the only exception.

The Seal Islands are composed of several small islets but little above high water, strung along near the coast for about 10 miles. Thence to Strogonof Point the land continues very low.

Port Haiden is said to be a good harbor, but we did not examine it. Should a survey show it to be safe and easy of approach, it will prove a great convenience to vessels employed on the northern part of Baird Bank. The approach to Port Haiden will be recognized by high bold headlands, which rise from its northern shore.

Chestakof Island, low and crescent-shaped, forms the seaward side of the harbor, the channel lying between its northern extremity and a reef which makes out from the land. The same low coast extends to Cape Menchikof in nearly a direct line, the high land of Port Haiden gradually receding from the coast.

The Ugashik, or Sulima River, lies to the northward of Cape Menchikof, and has been reported navigable for several miles by vessels of 14-feet draft. The schooner *Pearl* enters the river, but her captain reports a wide bar having intricate channels, strong currents, and usually a heavy swell. Ten feet is about all that can be carried in with safety. Once inside, it is reported to be a good harbor, but it can hardly be considered available for the ordinary purposes of fishing vessels.

Cape Grey, a bluff 243 feet in height, and a peculiar notched mountain some distance inland, are good landmarks for the river. The low coast continues from the cape

to the Ugaguk River, and thence to the Naknek River, with hardly a distinguishing feature, except Johnston's Hill, a solitary elevation 5 miles from the beach and about 9 miles S. ½ E. from the mouth of the Naknek. The coast sweeps in a graceful curve to the northward between Cape Grey and the Ugaguk, and thence to the eastward to the Naknek River. A gravel bank lines the coast in several places, behind which a narrow strip of water is seen, particularly at or near high tide.

The Naknek River may be considered as the head of deep-water navigation in Bristol Bay. The *Albatross* found anchorage in 6 fathoms about 6 miles southwest from Cape Suworof, the water shoaling rapidly to 3 fathoms toward the head of the bay. Vessels of moderate draft can pass the bar at high water, but there is hardly depth enough to float a ship's boat when the tide is out. It is deeper inside, however, and a small vessel may find anchorage with swinging room. There is a fishing station on the river which is visited periodically by a small steam tender. The South Head is in latitude 58° 42′ 04.3″ N., and longitude 157° 02′ 45.4″ W. High water, full and change, 1 hour 5 minutes; rise, 23 feet. Shoal ground makes off from the west shore, confining the channel in one place to about 3 miles in width. It may possibly be a middle ground with a channel on either side, but the conditions off Etolin Point seem to disprove this.

The Nushagak River is assuming considerable importance as the location of a trading station and of several large and well-equipped salmon-canning establishments. Protection Point, the entrance to the river, is 50 miles SW. by W. from the Naknek River, and, owing to swift currents and extensive shoals, it may be classed among the most intricate pieces of navigation in Bristol Bay. A 6-knot current is frequently encountered, hence the shifting of banks and shoals must be expected, and the necessity for the constant use of the hand lead becomes too obvious to require remark; indeed, the warning from a lead on each side will leave but a small margin of safety at times. The land on both sides of the entrance is very low, and it is difficult to recognize Etolin Point even under favorable conditions. A vessel from the westward would make the Walrus Group and follow the coast to Cape Constantine, and, having cleared the outlying shoals, stand in for Protection Point, which is difficult of recognition from a distance.

Nichol's Hills, 280 feet in height, are a cluster of rounded elevations 5 miles northwest of the above point, and are the first natural objects distinguishable on the peninsula. Bring them to bear west-northwest and stand in, keeping them on that bearing until Protection Point bears about south, and anchor, making due allowance for falling tide.

There is a pilot station on the Point, with a small flagstaff, on which a flag will be hoisted if the pilot is at home. He is an Esquimau, and speaks very little English, but he knows the channel. If he is not at the Point when the vessel arrives, he will probably be at Ekuk, and may be expected on board within a few hours if the weather is not too rough for his kayak. A stranger should not attempt to enter without a pilot, unless from necessity.

Clark's Point is 18 miles north by west from Protection Point, the usual anchorage being from half a mile to a mile above it.

Ekuk, an Esquimau village, is on the bluff nearly 3 miles below Clark's Point.

Clark's Point is a bluff 200 feet in height, beginning below Ekuk and extending 2 or 3 miles up the river, and thence to Nushagak. It varies from 100 to 150 feet in

height. The west side is generally lower, but from Coffee Point to the northward the bluffs rise from 50 to 200 feet.

The reconnoissance of the Lower Nushagak was made during the few days we were detained in the river. The principal points are located by triangulation, Clark's Point by astronomical observations, and the reduction of soundings to low water depends upon the tides during our stay. It is to be regretted that we were unable to extend the soundings to the west shore.

The Nushagak Packing Company have a cannery at Clark's Point, and there are three others, besides a trading station, in the river, the latter at Nushagak, formerly called Fort Alexander. Vessels of moderate draft can reach the canneries, and, with a little care, find anchorage with sufficient water even during the lowest tides. The timber line is well defined about 3 miles below the mouth of Wood River, and extends to the westward as far as the eye can reach. The weather was pleasant during our stay, and, from all reports, they have less fog in the Nushagak than in any other part of Bering Sea.

Clark's Point (foot of bluff) is in latitude 58° 49′ 14″ N. and longitude 158° 31′ 43.9″ W. High water, full and change, 0 hours 53 minutes, approximate; rise, 24 feet. Variation, 23° 40′ east.

Cape Constantine, the southeast extremity of land at the entrance to the Nushagak, is very low, and shoals extend 10 or 12 miles to the southward and eastward, making its approach in thick weather very dangerous. There is said to be a channel between the cape and the first shoal, but the report requires verification. The coast line increases in height to the westward of the cape, the headlands in Kulukak and Togiak Bays reaching an altitude of 500 feet or more.

The Walrus Group is composed of three islands and three rocks, all above water, extending 16 miles east and west, and about 6 miles north and south.

Round Island, the easternmost of the group, lies W. ½ S., 36 miles from Cape Constantine. It is nearly 2 miles in length, three-quarters of a mile wide, and about 800 feet high, its west end being in latitude 58° 36′ 09″ N. and in longitude 159° 57′ 51.7″ W.

Crooked Island is between 4 and 5 miles in length and 2 miles in greatest width. The eastern part is rather low, but toward the western extremity the elevation is nearly equal to that of Round Island. There is quite a large bay on the northeast side, but we did not examine it.

High Island, the westernmost of the group, is 4 miles in length, about a mile in width, and 900 feet or more in height.

The Twins are two isolated rocks 4 miles to the southward of Crooked Island, the larger 300 and the smaller 100 feet in height.

Black Rock, about 150 feet high, lies 1 mile to the northward of the south end of Crooked Island.

No other outlying dangers were seen in passing between the islands and the mainland. From 6 to 10 fathoms were found abreast of the group, the depth gradually decreasing to 3 fathoms off the north end of Hagemeister Island. We were near the shore, however, and would doubtless have found more water in mid-channel.

Hagemeister Island lies 9 miles west of High Island, and is 14 miles in length and 8 in width. It is mountainous except for about 5 miles at the north end. Shoal ground surrounds the island and extends from 20 to 25 miles to the eastward, including the area between Hagemeister and the Walrus Group.

Hagemeister Channel is about 16 miles in length and lies between the island of that name and the mainland. It is from 3 to 4 miles in width, but shingle spits contract it in two places to less than 2 miles. The least water was $4\frac{1}{2}$ fathoms. Good anchorage was found under Tongue Point, the shingle spit making out from the mainland about midway of the channel. From the above anchorage the *Albatross* stood directly to sea, passing within a mile of the southwestern extremity of Hagemeister Island; thence S. $\frac{1}{2}$ W., shoaling the water to 3 fathoms 7 miles from the island. Greater depths might possibly be found by taking a more westerly course. The tides are very strong through the channel. We were visited by a number of Esquimaux while at anchor under Tongue Point.

Cape Peirce is of moderate height and symmetrical form, while Cape Newenham is high, with sharp peaks and rugged lines. The *Albatross* found anchorage under the latter cape near Seal Rock during a southerly gale, and laid it out very comfortably, notwithstanding swift currents and heavy tide rips.

The Kuskokwim River is much dreaded by navigators on account of its extensive shoals, strong currents, etc. The *Albatross* ascended it between 35 and 40 miles without difficulty or delay, but encountered extensive shoals on her return. Thick weather and the lack of time prevented an extended examination. They commenced about 9 miles west-southwest from Good News Bay and extended in a westerly direction for 10 miles or more. There is a channel between the shoal and the land about 4 miles wide, having a depth of 5 fathoms. From a point 5 miles west-southwest from the west head of Good News Bay we stood direct for Cape Newenham, the least depth being 4 fathoms. Great quantities of fresh water are borne down the Kuskokwim by the rapid currents, and, while there have been no surveys by which changes can be noted, there seems no reasonable doubt that great alterations have taken place since Cook ascended the river in the last century.

METEOROLOGICAL CONDITIONS OF BRISTOL BAY.

The winds and weather in Bristol Bay and the other parts of Bering Sea visited by the *Albatross* from the last of May to the 1st of September, 1890, may be summarized in a few words.

Southwest winds prevailed, but we had them frequently from southeast to northwest. It was boisterous weather nearly half the time, but seldom rough enough to interfere with our work. We had several summer gales of moderate force, but no severe storms. Fog and mist prevailed, and a clear day was the rare exception. The tidal currents were strongest in the vicinity of Unimak Pass and at the head of the bay; they were greatly affected, however, by the winds. The flood stream set to the northward and slightly inshore along the coasts of Unimak and the peninsula, the ebb to the southward and offshore. The former was invariably the stronger, and probably found an outlet by sweeping past Cape Constantine in the direction of Cape Newenham. There has been no systematic study of the currents of Bering Sea, and the almost constant fogs prevent the navigator from adding much to our meager knowledge concerning them.

THE CODFISHING BANKS OF BRISTOL BAY.

The codfish banks of Bristol Bay extend from Unimak Pass, along the Bering Sea shores of the island of that name and the Alaska Peninsula, to Cape Chichagof, and thence to the Kulukak Ground and the vicinity of Cape Newenham.

Slime Bank extends from Northwest Cape of Unimak to the vicinity of Amak Island, embracing depths from 20 to 50 fathoms. It is about 85 miles in length, 17 in average width, and covers an area of 1,445 square miles. The character of the bottom is generally black sand and gravel, pebbles being frequently added, with rocks near shore and mud in the greater depths.

The bank received its name from the fishermen on account of the number of medusæ or jelly fishes found on it. The species was unknown to our naturalists, but it may be described as brownish or rusty in color, from 6 to 18 inches in diameter, and with long slender tentacles well covered with stinging cells. These jelly fishes seem to inhabit an intermediate space near the bottom, very few being seen on the surface. Their numbers increase during the season until they become a great nuisance to the fishermen. Codfish of fair size and good quality were very plentiful over the whole bank, and scattering specimens of small halibut were taken.

A well-found fishing schooner could anchor anywhere on this ground between May and September with an even chance of being able to lay out any gale she would encounter. Shaw Bay affords excellent protection against winds from southeast to southwest.

Baird Bank has been named by the writer in honor of the late Prof. Spencer F. Baird, the first U. S. Commissioner of Fish and Fisheries, through whose untiring efforts the great scheme of deep-sea fishery investigation was inaugurated. This bank is the largest and most valuable of the fishing grounds yet discovered in Bering Sea. Commencing in the vicinity of Amak Island, it stretches along the coast of the peninsula to Cape Chichagof, 230 miles, with an average width of 40 miles, and thus covers an area of 9,200 square miles. The depths range from 15 to 50 fathoms, with a bottom of fine gray sand, occasional spots of black sand, black sand and gravel, and a few rocky patches near the shore.

Well-equipped fishing vessels can anchor anywhere on Baird Bank and lay out such winds as she would be likely to encounter during the summer months. The peninsula will afford a weather shore for southeast winds, and Amak Island offers fairly good protection on its southeast and southwest sides. Port Möller and Herendeen Bay will be ports of call for fishermen when they become better known. Port Haiden also may become available after it has been surveyed.

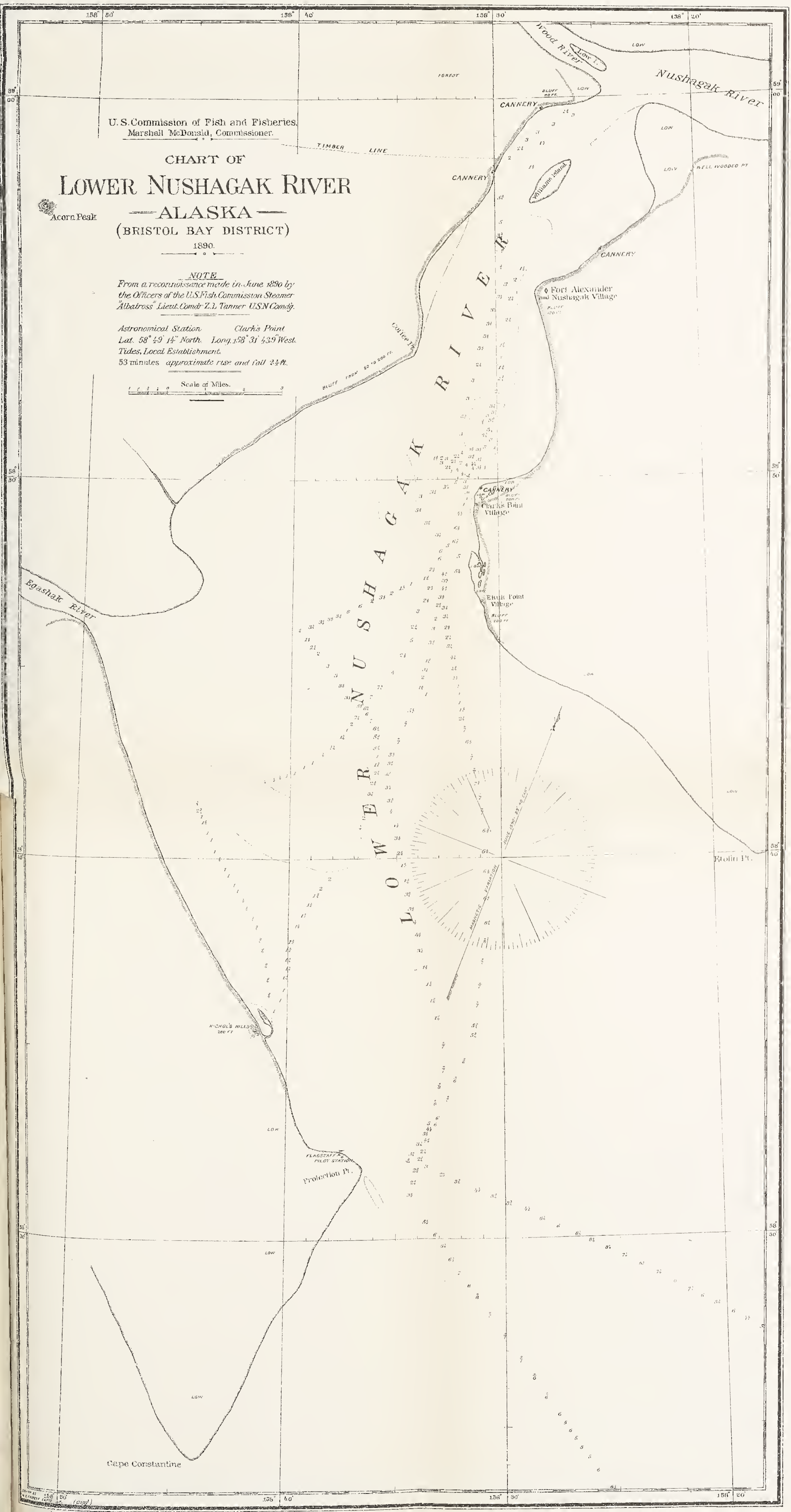
We found codfish in great abundance and of good quality over the whole bank, but the best fishing ground is without doubt in depths between 25 and 40 fathoms, and the Port Möller region is the most prolific. Fish taken near shore were smaller and apparently not in as good condition. Codfish are found on the Kulukak Ground and in the region of Cape Newenham, but they are smaller and inferior in quality to those on the shores of Unimak and the peninsula.

Codfish have their enemies in Bering Sea as well as in other parts of the world. Many wounded fish are seen, particularly in spring and fall, after the passage of the seals into and out of the sea. This phenomenon is observed more noticeably near the passes between the Aleutian Islands. Bering Sea also suffers, in common with other

prolific grounds that are not much fished upon, in that numbers of fish are left to die of old age or other natural causes. At a certain age the fish become weak and more liable to be infested with parasites, all of which is soon apparent from the general condition of the victims. This is a trouble which decreases, however, as a bank becomes more generally fished.

Scattering specimens of small halibut of fine quality were found on Baird Bank. Flounders of several species, some of them excellent fish, were also taken in the beam trawl wherever it was lowered in Bering Sea.


U.S. Commission of Fish and Fisheries.
Marshall McDonald, Commissioner.
CHART OF
BRISTOL BAY AND ALASKA PENINSULA
ALASKA
1890
NOTE
Compiled from all accessible data and showing results of recent investigations made by the Officers of the U.S. Fish Commission Steamer "ALBATROSS" Lieut. Commander Z.L. Tanner, U.S.N. Commanding.
TIDES
H.W.F. & C. Approximate.
Nushagak River, Clark's Pt. 0h 53m Rise of tide 24 ft.
Naknek River 1h 05m " " " 23 "
Herendeen Bay, Mine Harbor 8h 0m " " " 15 "
Kuskokwim Bay 6h 15m " " " 13½ "
KUSKOKWIM BAY
BRISTOL BAY
KULUKAK BAY
Kulukak Ground
Togiak Bay
Shoal Ground
Walrus Ids.
Cape Pierce
C. Newenham
Cape Constantine
Nushagak River
Wood R.
Aleknagik Lake
Naknek River
Kvichak Bay
Ugashik Riv.
Cape Menchikof
BAIRD BANK
ALASKA PENINSULA
Port Moller
Port Heiden
Chignik Bay
Semidi Islands
SLIME BANK
UNIMAK ISLAND
Unimak Pass
Unimak Bay
Cold Bay
Pavlof Bay
Unga Strait
Stepovak Bay
SHUMAGIN ISLANDS
Sannak Ids.
SANNAK BANK
Sandman Reefs
Sannak Reefs
DAVIDSON BANK


U. S. Commission of Fish and Fisheries,
Marshall McDonald, Commissioner.
CHART OF
LOWER NUSHAGAK RIVER
ALASKA
(BRISTOL BAY DISTRICT)
1890.
NOTE
From a reconnoissance made in June 1890 by the Officers of the U.S. Fish Commission Steamer "Albatross" Lieut. Comdr. Z. L. Tanner U.S.N. Comdg.
Astronomical Station Clark's Point
Lat. 58° 49' 14" North. Long. 158° 31' 43.9" West.
Tides, Local Establishment.
53 minutes approximate rise and fall 24 ft.
Scale of Miles.
Acorn Peak
Wood River
Low I.
Nushagak River
CANNERY
TIMBER LINE
Williams Island
WELL WOODED PT.
Fort Alexander and Nushagak Village
Coffee Pt.
NUSHAGAK RIVER
LOWER NUSHAGAK RIVER
Clarks Point Village
Ekuk Point Village
Egashak River
Etolin Pt.
NICHOLS HILLS
FLAGSTAFF PILOT STATION
Protection Pt.
LOW
Cape Constantine


U.S. Commission of Fish and Fisheries.
Marshall McDonald, Commissioner.
CHART OF
PORT MOLLER AND HERENDEEN BAY
ALASKA
1890.
From a survey made by the Officers of the U.S. Fish Commission Steamer "ALBATROSS" Lieut. Comm'dr. Z. L. Tanner, U.S. Navy Command'g.
NOTE
Soundings in fathoms reduced to mean low water
‡ Astronomical position, Low Point Mine Harbor. 55° 45′ 24″ North Lat. 160° 41′ 21″ West Long.
Tides: Local Establishment approximate, VIII hours. Rise and Fall 15 ft.
Scale of Miles.
(Nautical)
PORT MOLLER
HERENDEEN BAY
DEER ISLAND
Shoal
Entrance Pt.
Harbor Pt.
Fawn Pt.
Doe Pt.
Pt. Divide
Hague Channel
Johnston Channel
Half Tide Rock
Eagle Rock
COAL BLUFF
COAL MINE
Marble Pt.
Shingle Pt.
Bluff Pt.
Low Pt.
MINE HARBOR
Crow Pt.
Lawrence Valley
Gravel Pt.
Gull Pt.
Bold Bluff Pt.
Grass Valley
Deer Valley
160° 50′
160° 30′
160° 40′
161° 00′

15.—REPORT UPON AN INVESTIGATION OF THE FISHING GROUNDS OFF THE WEST COAST OF FLORIDA.

BY A. C. ADAMS AND W. C. KENDALL.

(With Plate CXI and one text figure.)

INTRODUCTION.

The Fish Commission schooner *Grampus*, Capt. A. C. Adams, commanding, left Wood's Holl, Massachusetts, January 14, 1889, for the Gulf of Mexico, under instructions to investigate the physical and biological characteristics of the red snapper and grouper grounds off the west coast of Florida, and the shore fishes and fisheries between Biscayne Bay and Cedar Keys. Dr. James A. Henshall, secretary of the Cincinnati Society of Natural History, and Mr. W. C. Kendall were assigned to the *Grampus* as naturalists, the former to conduct the coast inquiries, the latter to remain with the schooner on the offshore work.

The instructions for the offshore explorations were essentially as follows: The area marked out for examination was comprised between the depths of about 15 and 50 fathoms, beginning about 20 miles north of the Tortugas Islands, and extending to within 20 or 30 miles of Cape San Blas. The work was to be begun at the south and carried northward to such extent as the time and weather would permit. The bottom varies considerably in different parts of this region, being rich and affording good fishing in some places, while in others it is poor and devoid of much life. The object of the cruise was, if possible, to determine the precise localities to which red snappers and groupers resort in greatest abundance. The investigation was to be conducted in the following manner: Lines of dredging and fishing stations were to be run across the plateau in an east and west direction, or practically parallel with the lines of latitude, at intervals of about 10 miles. Continuous trials for fish, by the methods employed by the red-snapper fishermen, were to be made along these lines, and the bottom was to be examined by means of the dredge at regular stations located about 10 miles apart. Temperature and other physical and meteorological observations were also to be recorded.

In the coast work Dr. Henshall was instructed to collect and study the fishes along the region above defined, and also the marine invertebrates with special reference to the useful species of crustaceans, sponges, etc. With respect to the fishes, he

was to pay particular attention to the abundance, distribution, and habits of those species which might be of economic importance as food, bait, or otherwise. He was also to observe the methods and collect the statistics of the fisheries between Biscayne Bay and Charlotte Harbor.

The *Grampus* reached Key West on January 27, and a short delay ensued in making the necessary preparations for the work. Dr. Henshall arrived February 5, and on the 9th the *Grampus* proceeded to convey him as near as possible to Biscayne Bay, where he was to begin his collecting trip along the coast. February 11 Dr. Henshall left the *Grampus* off Indian Key, to make his way eastward along the Florida reefs and by the first safe passage into Biscayne Bay. He was provided with the large seine boat belonging to the schooner, a dory, and the necessary fishing appliances, camping utensils, and provisions; his party consisted, besides himself, of a competent pilot, and of a seaman and the cabin boy from the *Grampus*. It was arranged that he should meet the *Grampus* about March 4, at Charlotte Harbor.

The *Grampus* returned to Key West from Indian Key on the 12th, and was there joined by Mr. Kendall on the same day. She began her investigations February 14, and continued them until March 27; but the season proved too short to carry them farther northward than about 100 miles, especially as much stormy weather was encountered. The average width of the region gone over was about 70 miles, making the total area examined about 7,000 square miles.

On the following pages the work is described under the several east and west lines of observing stations, which are ten in number and are designated by the letters A to J, inclusive. These lines and the dredging stations are represented on the accompanying chart (Pl. CXI). The seventy-five dredging stations made are numbered from 5050 to 5124, inclusive. Of the animals obtained, only the fishes, brachyuran crustaceans, and mollusks have so far been identified and can be referred to specifically. Tables are given of the dredging stations, of the snappers and groupers caught, and of the meteorological observations. The report upon the shore fishes is being prepared by Dr. Henshall and Dr. D. S. Jordan, and will be published separately.

During the night of February 19, after completing line B, and while at anchor, a strong breeze sprang up, parting the anchor cable and obliging the schooner to return to Key West for a new shackle. A week was lost by this accident, as the schooner did not get back to her grounds until February 26, being detained by stormy weather. The schooner generally anchored on the ground during the night, so that she could take up her work again the next morning without loss of time.

On March 3, after completing line D, the schooner proceeded to Charlotte Harbor, in accordance with the agreement made with Dr. Henshall, meeting him there on the 4th. Supplies were obtained and plans laid to again meet Dr. Henshall at Port Tampa, and after a short delay, occasioned by sickness on board and calm weather, the *Grampus* reached line E about noon of the 10th. Work was carried on continuously from that time until March 27, and the *Grampus* made Port Tampa on March 29, Dr. Henshall also arriving on the same day. Mail was received at that place instructing the *Grampus* to proceed to New York, and further operations in this region were therefore suspended for the season.

The *Grampus* left Port Tampa April 4. Head winds detained her two days at the Tortugas, where shore collections of fishes were made. Departure was taken from Key West April 15, and New York was reached on the 25th of that month.

DETAILED ACCOUNT OF THE INVESTIGATION.

LINE A.—FEBRUARY 15 TO 17; DREDGING STATIONS 5050 TO 5058.

Dredgings.—Line A was carried nearly due west from shoal water, the latitude varying only from 25° 01′ N. to 25° 02′ 49″ N. The first station, No. 5050, was made at 8.30 a. m., February 15, in a depth of 15½ fathoms. The dredge was dragged for half a mile but brought up only white mud with no apparent life. The surface net was also towed at the same place, securing an abundance of copepods, salpæ, and fish eggs. Station 5051 was in 18 fathoms, and covered a distance of one-quarter of a mile. The contents of the dredge consisted chiefly of broken shells, with one large shrimp and several other small crustaceans. At station 5052, 21 fathoms, distance traversed one-eighth of a mile, the bottom consisted of white mud and broken shells. Copepods, salpæ, and fish eggs were obtained in the surface net near the same place. Station 5053 was made at 7.40 a. m., February 16, depth 25 fathoms, distance traversed one-quarter of a mile, bottom consisting of a light-colored, fine sandy mud, with broken shells, dead corals, sponges, and bryozoans. A small crab (*Lambrus agonus*) was also taken in the dredge. Station 5054 was in 29 fathoms, distance traversed one-quarter of a mile. Only a few broken shells and a crab (*Neptunus spinicarpus*) were brought up in the dredge. Station 5055, in 32 fathoms, drift one-eighth of a mile, afforded broken shells and corals, fragments of sponge, one starfish and a few small crustaceans (*Podochela gracilipes, Ethusa*, sp., etc.). At station 5056, 36 fathoms, drift one-eighth of a mile, the dredge brought up only sand and broken shells, one small crab, and an annelid. The bottom was probably smooth, consisting of light-colored sand. Station 5057 was occupied at 6.15 a. m., February 18, depth 37 fathoms, drift three-quarters of a mile. The contents of the dredge consisted of sand, shells, broken coral, nullipores, two small fishes, and two crabs (*Lambrus fraterculus* and *Ethusa*, sp.). The first line (line A) was completed the same day at station 5058, 44½ fathoms, drift one-tenth of a mile, bottom composed of sand and broken shells. About 4½ miles west of the last station the water deepened to 57 fathoms.

The bottom along this line varied from mud to sand, with broken shells at most stations. The sand and mud were light-colored in all places.

Fishing.—Fishing trials were made at each of the dredging stations, and generally at intervals of five to ten minutes between the stations during the daytime. This line afforded more fish (red snappers and groupers) than any of the others farther north. Nothing was taken, however, during the morning of the first day, or until about the close of the second dredge haul (station 5051). At the first station the bottom consisted of white mud with no life, and at the second chiefly of broken shells, apparently with very few animals living upon it. While drifting, however, on this haul, about 1.15 p. m., hard bottom was struck and three fine red snappers were taken immediately by one person. Fishing was continued for about twenty-five minutes, and six lines were out during a part of the time, but only one more red snapper was caught, the vessel soon drifting to muddy bottom, where there seemed to be no fish. Judging by the number of bites that were felt, had the lines been ready in the beginning, and had the ship been supplied with better bait, more gratifying results would have been obtained.

The next fish, two red snappers, averaging 27½ inches in length, were taken at station 5052, although the bottom at that place was soft. No bites were felt between stations 5051 and 5052. The vessel anchored on the ground at 6 p. m. on February 15, and during the evening the following were taken on hand lines: Eight or ten sailors' choice (*Lagodon rhomboides*), two small red-mouthed grunts (*Hæmulon rimator*), two squirrel fish (*Serranus formosus*), and a crab (*Calappa marmorata*).

Two trials were made on the run to station 5053, but no fish were taken, although the soundings were considered favorable. Better success was had at the latter station, however, where trial No. 3 was made while the dredge was out, the bottom containing considerable life although composed of sandy mud. Five lines were kept out about twenty-five minutes, taking thirty-one red snappers, one red grouper, and two black groupers. The former species was very abundant, and a good fare could probably have been obtained in a comparatively short time. The average length of the snappers was 24 inches; nine of them measured 29 inches each, and the three smallest 13½ inches each. The largest grouper measured 36 inches and weighed 22½ pounds.

No bites were obtained between stations 5053 and 5056, nor at the latter station. After leaving station 5056 two large red snappers and one large grouper were caught, at 5.30 p. m. (trial 4). The snappers measured 33 and 36 inches, respectively, and the grouper 35 inches. This trial was made just before dark, and other fish could be felt nibbling at the bait, but the vessel did not lay to long enough to secure a larger catch. Had it been earlier in the day large fish would probably have been taken in abundance. In this same locality a small shark (*Carcharhinus terræ-novæ*) containing a fish (*Monacanthus hispidus*) in its stomach was captured.

No fish were taken at station 5057, but while at anchor during the evening of February 16 (trial 5) two red groupers, each measuring 21 inches, were obtained in 37 fathoms, sand, broken shells, and corals.

The next morning at 9 o'clock one black grouper, 28 inches long, was caught 3 miles west of station 5057, of the previous day; depth, 38 fathoms; sandy bottom, with broken shells and corals. Nothing was obtained at station 5058. Three flying fish were seen on February 16.

LINE B.—FEBRUARY 17 TO 19; STATIONS 5059 TO 5067.

Dredgings.—Line B was begun at the outer or deep-water end and was carried eastward along a somewhat irregular line, varying from latitude 25° 12′ to 25° 17′ N. Station 5059 was in 50 fathoms, drift one-eighth of a mile; contents of dredge, sand and broken shells. At the next station, 5060, 38 fathoms, drift three-eighths of a mile, the dredge brought up sand, broken shells and coral, and some small crustaceans. Station 5061 was in 36 fathoms, drift one-half a mile; bottom, sand and broken shells. One small fish (*Rhypticus pituitosus*) and one crab were the only signs of life taken in the dredge. Copepods, salpæ, and fish eggs were obtained in the surface net. At station 5062, 30½ fathoms, drift one-half a mile, the bottom also consisted of sand and dead shells, of which an entire dredge-load was secured, but it seemed to be devoid of much life. At station 5063, 27 fathoms, drift one-eighth of a mile, mud, sand, and broken shells, several small crabs and lancelets (*Branchiostoma lanceolatum*) were taken in the dredge. Station 5064 was in 24 fathoms, drift, one-eighth of a mile. The bottom was composed of soft mud, sand, and broken shells; several

pieces of sponge, a few crabs, and a number of lancelets were obtained. The bottom at station 5065, 19½ fathoms, drift one-tenth of a mile, consisted of hard sand and broken shells, a few worms being the only visible signs of life. At station 5066, 17 fathoms, gravel and broken shells, together with a few specimens of *Branchiostoma* were obtained from the bottom, while the surface net captured copepods, larval crabs, fish eggs, and young fish. The inner end of the line was reached at station 5067, depth 14½ fathoms, the bottom being hard. Broken shells and a few small shrimps were brought up in the dredge.

Fishing.—Snappers and groupers were taken at only two places along this line (trials 7 and 8). A number of small sharks were seen alongside at station 5059 and one was captured. One flying fish was also observed. The fishing trials were unsuccessful at stations 5059 and 5060, and only one was made between those stations, as the wind was blowing strong. While at anchor on the evening of February 17, in the position of station 5061, 36 fathoms, sand and shells, one red snapper, measuring 28 inches, was caught and a number of bites were felt, but they may have been due to other fish. After leaving station 5061, trials with hand lines were made very close together, good bait (fresh snapper) being used, but without obtaining any fish, although the bottom seemed to be as favorable as on line A. Between stations 5061 and 5062 a school of six or eight porpoises (*Prodelphinus plagiodon*) played around the bow, and one male, measuring 6 feet 11 inches long, was harpooned.

In the neighborhood of station 5064 the bottom was soft and sticky, with no indications of fish, and this continued some distance toward 5065. At the latter station, 19½ fathoms, hard sand and broken shells, groupers were plentiful, nine red and three black groupers being taken inside of fifteen minutes and also three red snappers, averaging a little over 23 inches in length. Four or five groupers at a time could be seen swimming up towards the surface. From this point to the end of line B no fish were obtained, although all the conditions seemed favorable to their existence. At station 5067 a turtle and a large shark were seen at the surface.

LINE C.—FEBRUARY 26 TO 28; STATIONS 5068 TO 5074.

February 20, about 1 a. m., the anchor cable parted, due to a heavy chop sea, and the schooner was obliged to return to Key West for a new shackle. During the afternoon of that day, while proceeding southward, a large number of frigate mackerel (*Auxis thazard*) were caught by trolling from the stern, with a piece of white rag for bait. While returning to the fishing ground on February 25, a short visit was made to Marquesas Key, where shore collections were made.

Dredgings.—Line C was in latitude 25° 23′ to 25° 24′ 30″ N. and extended from a depth of 17 to one of 52 fathoms. Seven dredging stations were made, as follows: No. 5068, 17 fathoms, coarse gravel, with broken corals and shells, afforded several specimens of *Branchiostoma*, worms, a small crab, and a bivalve mollusk (*Tellina antoni*). Station 5069, 23 fathoms, soft gray sandy mud, gave a few small crustaceans and one *Bregmaceros atlanticus.* Station 5070, 26½ fathoms, hard sandy bottom with broken shells, the dredge also securing a small sponge, a small crab, and a hermit crab protected by a fragment of coral. Station 5071, 30 fathoms, fine gray sand, with black specks and broken shells, afforded several species of crustaceans and one sea urchin. Station 5072, 33½ fathoms, sand and broken shells, algæ, corals, sponges,

bryozoa, and small crustaceans, including three species of crabs, each represented by a single specimen, namely, *Leptopodia sagittaria*, *Arachnopsis filipes*, and *Cymopolia*, sp. At station 5073, 38 fathoms, the dredge brought up sand, broken shells and corals, fragments of sponges of several kinds, ascidians, two sea urchins, three ophiurans, and small crabs, including *Podochela gracilipes*. Station 5074, in 52 fathoms at the outer end of the line, afforded a rich hard bottom, with alcyonarian corals, small barnacles, crabs, algæ, and other forms of life.

Fishing.—Line C was begun February 26 and finished on the 28th. No snappers or groupers were taken along this line, and there were no indications of those fish, although the vessel was provided with good fresh bait. Frequent trials were made between as well as at the several dredging stations, but altogether without any success. Inside of a depth of 33 fathoms, the bottom ranged from soft to hard, with very little life upon it. At station 5072 and beyond the bottom was much richer, but the fishing trials proved equally fruitless there. At some of the inner stations specimens were taken of the frigate mackerel (*Auxis thazard*), called by the people in this region Spanish mackerel, and flying fish were numerous during the 28th. A number of porpoises were also seen on the latter day.

LINE D.—FEBRUARY 28 TO MARCH 3; STATIONS 5075 TO 5082.

Dredgings.—This line was carried eastward from deep water chiefly along the parallel of 25° 34′ N. latitude, deviating in one place to 25° 38′ 21″ N. Eight dredging stations were made, the water shoaling from 52½ to 15½ fathoms. Station 5075 was in 52½ fathoms, the bottom consisting of gray sand, broken shells and corals. Sponges and a large pycnogonid were the principal animals obtained. At station 5076, 39 fathoms, the dredge brought up coarse gray sand with broken shells and corals, algæ, sponges, one small fish, pycnogonids, small shrimps, and small crabs (*Arachnopsis filipes*, *Lambrus agonus*, and *Calappa*, sp.). Among the shells were specimens of *Muricidea floridana*. Station 5077, 33 fathoms, coarse gray sand, broken shells and corals, afforded specimens of two gastropod mollusks (*Fusus eucosmius*, *Nassa ambigua*), small crabs, a large hermit crab, a sea urchin, and a small fish belonging to an undescribed genus. At station 5078, 30 fathoms, sand and broken shells, the dredge secured a large pycnogonid, and several species of crabs (*Podochela gracilipes*, *Arachnopsis filipes*, *Lambrus fraterculus*, and *Cymopolia*, sp.). In about this same position the surface net was towed for nearly a mile, taking fish eggs, pteropod mollusks, copepods, salpæ, and small jelly fishes. Station 5079, 27 fathoms, afforded sand (apparently a hard bottom), and three small crabs representing *Lambrus agonus* and other species. At station 5080, 25 fathoms, sand and broken shells, the dredge brought up a small eel belonging to a new species (*Sphagebranchus kendalli* Gilbert), some sponges, and small mollusks (*Liocardium lævigatum*, *Corbula dietziana*, *Oliva literata*, *Nassa ambigua*, *Polynices lactea*).

Station 5081 afforded fine sand and mud, in 20 fathoms, with small crabs (*Neptunus spinicarpus*) and mollusks (*Oliva literata*). Station 5082 was at the inner end of the line, in 15½ fathoms, the bottom consisting of gray sand and broken shells, from which the dredge brought up only fragments of sponge, nullipores, and a compound ascidian containing an anomouran crustacean.

Fishing.—Only two groupers and one red snapper were taken along line D. The bait was fresh, live fish from the well being used. The bottom in several places indicated good feeding grounds. The first fish, two large black groupers, were captured at station 5076, 39 fathoms, where the bottom consisted of coarse gray sand with fine broken corals and shells, and contained an abundance of life. At station 5080, 25 fathoms, one red snapper was secured, weighing 18 pounds and measuring 30 inches in length. There was much difficulty in fishing along part of this line, owing to stormy weather, which may also have been responsible for the small number of fish captured.

A small shark (*Carcharhinus terræ-novæ*) was caught at station 5075, and one frigate mackerel at the anchorage in the evening of the same day. Between stations 5081 and 5082, one crevalle was taken on the drail line.

VISIT TO BIG GASPARILLA ISLAND, ETC.

March 4, about 9:45 a. m., the *Grampus* anchored off Big Gasparilla Island, in accordance with the agreement made with Dr. Henshall, who arrived there on the same day. Supplies were obtained from Punta Gorda and some fishing was done in the vicinity of the anchorage. The small seine was hauled in a bayou and once on the outside, in the latter place securing sheepshead and catfish, and in the former pipe fish, sea horses (*Hippocampus*), silversides, cyprinodonts, young flounders, crabs, etc.

Several hauls of the large seine on Gasparilla, March 6 and 7, resulted in the capture of sheepshead, catfish, Spanish mackerel, file fish, two menhaden, drum, many halfbeaks, anchovies, herring, two mullet, one shark (*Reniceps*), squids, etc. March 7 Dr. Henshall and his party left in the seine boat. March 8 the seine was hauled on Lacosta Island, with the following results: A large number of sheepshead, halfbeaks (*Hemirhamphus*), sailors' choice (*Lagodon rhomboides*), garfish (*Tylosurus marinus*), flounders, gurnards (*Prionotus*), redfish (*Sciæna ocellata*), Milner's pagellus (*Pagellus milneri*), drum, etc. Many porpoises were also seen in the cove. Just after leaving Charlotte Harbor, on the 9th, squirrel fish (*Serranus formosus*) and whiting (*Orthopristis chrysopterus*) were caught with a small hand line. It is important to note that the water taken on board at Gasparilla caused sickness to some of the officers and crew.

LINE E.—MARCH 10 AND 11; STATIONS 5083 TO 5090.

Dredgings.—Line E, consisting of eight dredging stations, was carried chiefly along latitude 25° 44′ 32″ N., beginning in shallow water near the coast and ending in a depth of 53 fathoms. The results of the several dredge hauls were as follows: Station 5083, 15 fathoms, gravel, broken shells and coral, one small crab and a gastropod mollusk (*Natica canrena*). Station 5084, 19 fathoms, sand, broken shells, nullipores, a few specimens of *Branchiostoma*, small shrimp, worms, and mollusks, among the latter being *Semele cancellata* and *Turritella acropora*. Station 5085, 24 fathoms, hard fine sand, broken shells and corals, a few small crabs (*Cymopolia*, sp., etc.), and the following mollusks: *Oliva literata*, *Murex chrysostoma*, and *Ocinebra nucea*. Station 5086, 28 fathoms, mud, fine sand, and broken shells. Station 5087, 31 fathoms, fine sand and broken shells, one ophiuran and a sponge. Station 5088, 34 fathoms, fine sand and broken shells, fragments of sponge, ascidians, bryozoa, and small crabs (*Leptopodia sagittaria*, *Neptunus spinicarpus*, *Callidactylus asper*). Station 5089, 38 fathoms, sand, nullipores, one crab (*Lambrus fraterculus*), and a small fish (*Antennarius*, sp.). Station 5090, 53 fathoms, sand and broken shells, with specimens of free crinoids (*Antedon*.)

Fishing.—At the first station on this line, 5083 (trial 11), exceedingly good results were obtained. The depth was 15 fathoms; bottom, black gravel, broken shells and coral, but very little life being taken in the dredge. The fish captured were thirty-two red snappers and two red groupers, the former averaging 25 inches, the latter 27 inches in length. Captain Adams considers that this locality promises good fishing. In seeking this position, and when half a mile north of it, a line was put over to ascertain the depth. One grouper was taken on it, and four or five others followed it to the surface. No fish were caught, however, beyond this station to the end of the line. The weather was rather stormy and it was difficult to fish between stations. Had it been smoother, some fish might have been taken, but the experience has been that where fish occur they bite readily and quickly, and indications of them are found as soon as fishing begins.

LINE F.—MARCH 11 TO 16; STATIONS 5091 TO 5096.

Dredgings.—This line was made chiefly in about 25° 54′ N. latitude and contained six dredgings, ranging from deep to shallow water, as follows: Station 5091, 49 fathoms, fine sand and broken shells, one small crab and a specimen of *Hippa*. Station 5092, 31 fathoms, gravel, sand with black specks, and broken shells, a starfish, sea-urchin, crabs, shrimps, etc. Station 5093, 28 fathoms, sand with black specks, broken shells and coral, alcyonarians, ophiurans, shrimp, etc. The towing net at this place secured jellyfishes, salpæ, and a small fish at the surface. Station 5094, 25 fathoms, coarse gravel, broken shells, and a single specimen each of sponge, crab, and starfish. Copepods, salpæ, small fishes and fish eggs were taken abundantly in the surface tow net. Station 5095, 20½ fathoms, gray sandy mud, a shrimp, crab (*Neptunus spinicarpus*), and a small eel, apparently *Ophichthys punctifer*, but too young to be positively identified. Station 5096, 16 fathoms, gray sandy mud with black specks, two specimens of a worm and two crabs (*Munida*).

Fishing.—Line F was begun in a depth of 49 fathoms. The sea was rough, and no fish were caught, but a spotted porpoise (*Prodelphinus plagiodon*), measuring 6 feet 10 inches long, was harpooned in the vicinity of station 5091. A school of about thirty of these porpoises had been playing around the bow. The indications for red snapper, however, were not favorable.

March 12 the weather was too severe for continuing the dredging and the schooner lay at anchor in latitude 25° 52′ N., longitude 83° 31′ W., 40 fathoms, hard bottom. During the morning four red snappers, averaging 31½ inches in length, and two black groupers, averaging 33 inches in length, were captured, and in the afternoon two red snappers, the length and weight of which were not ascertained. The fish appeared to be very abundant and could be felt biting at the hooks, but they did not hold on well, and only those above recorded were actually taken on board. During the night the schooner drifted about 2 miles northwest, bringing up in about latitude 25° 58′ N., longitude 83° 30′ W., depth 48 fathoms. On the morning of March 13, one black grouper, 38 inches long, and one red snapper, 32 inches long, were captured in this position.

The next fish, three red snappers, averaging 24⅝ inches in length, were caught at station 5094 (trial 14), the depth being 25 fathoms, the bottom consisting of coarse

sand, broken shells and corals, and the dredge bringing up very few evidences of life. March 15, during which stations 5092 to 5095 were made, was pleasant, and the trials were carried on to good advantage, but the fish seemed to be scattered. On the morning of March 16, a short distance to the eastward of station 5095, one red grouper measuring 19 inches long was taken. This was the last capture made on Line F.

LINE G.—MARCH 17 AND 18; STATIONS 5097 TO 5104.

Dredgings.—Line G was run somewhat irregularly, deviating between latitude 26° 04′ and latitude 26° 13′ N. Eight dredging stations were made, the first in a depth of 12, the last in 51 fathoms. They may be described as follows: Station 5097, 12 fathoms, fine gray sand and broken shells, bryozoans and one shrimp. Station 5098, 18 fathoms, hard sand, broken shells, a sponge, ascidians, and the following mollusks: *Arca noæ*, *Crepidula convexa*, *Polynices lactea*. Station 5099, 21½ fathoms, sand and broken shells; sponges, hydroids, crabs (*Leptopodia sagittaria* and *Cyclois bairdii?*), and other small crustaceans, one fish (*Ophidium*, sp.), and several species of bivalve mollusks (*Lucina crenulata*, *Chama congregata*, *Liocardium lævigatum*, and *Venus pygmæa*). Station 5100, 26 fathoms, black gravel, mud, broken shells, and a few ophiurans. Station 5101, 30 fathoms, black gravel, coral sand, broken shells; worms, sea-urchins, and crabs (*Cryptopodia concava*, *Cymopolia*, sp.). Station 5102, 33 fathoms, gravel, coral sand, mud; ophiurans, worms, gastropod mollusks (*Fusus eucosmius*), and small crabs (*Podochela gracilipes*, *Lambrus agonus*, *Callidactylus asper*, young). Station 5103, 36 fathoms, fine sand; sponges, bryozoans, ophiurans, ascidians, and small crabs. Station 5104, 51 fathoms, coarse sand, broken coral; a large number of free crinoids (*Antedon*, sp.) and a few small crabs (*Arachnopsis filipes*, *Lambrus agonus*, *Lambrus fraterculus*, *Iliacantha subglobosa*, and *Carpoporus papulosus*).

Fishing.—Only three fish, all of which were red groupers, were taken along Line G. The first was at station 5098 (trial 16), 18 fathoms, hard sand, length 23½ inches; the second at station 5099 (trial 17), 21½ fathoms, sand, length 26 inches; and the third at station 5100 (trial 18), 26 fathoms, gravel and mud, length 26 inches. One squirrel fish (*Serranus formosus*) was obtained at station 5097, and one frigate mackerel was caught by trolling at station 5100.

LINE H.—MARCH 18 TO 22; STATIONS 5105 TO 5111.

Dredgings.—Seven dredging stations were made along this line in latitude 26° 17′ 30″ to latitude 26° 20′ N., extending from a depth of 56 fathoms to one of 16½ fathoms, as follows: At station 5105, 56 fathoms, the dredge brought up nothing, but the lead indicated sand. Station 5106, 36 fathoms, sand, a few broken shells; large quantities of nullipores, green algæ, sponges, ascidians, small crustaceans, including the following four species of crabs: *Podochela gracilipes*, *Neptunus spinicarpus*, *Ethusa*, sp., and *Cymopolia*, sp., a sea-horse (*Hippocampus hudsonius*), etc. Station 5107, 31 fathoms, sand and broken shells; sea-urchins, one small holothurian, crabs (*Neptunus spinicarpus*, *Lambrus agonus*), and two species of gastropod mollusks (*Turritella acropora*, *Turbo crenulatus*). Station 5108, 27 fathoms, sand, sponges, crabs (*Lambrus fraterculus?*, *Neptunus spinicarpus*, *Acheloüs*, sp., *Cymopolia*, sp.), shrimps and other crustaceans, mollusks (*Muricidea floridana*, *Turritella acropora*, *Turbo crenulatus*), and a small fish (*Gillellus semicinctus*). Copepods, salpæ, etc., were taken in the surface tow net. Station 5109,

24 fathoms, sandy mud with black specks, broken shells; two ophiurans, one small fish (*Bregmaceros atlanticus*), shrimps, one crab, and two species of mollusks (*Dentalium matara*, *Distortrix reticulata*). Station 5110, 21 fathoms, sand with black specks, broken shells; one small sponge, crab (*Pericera cornuta?*), and gastropod mollusk (*Fasciolaria tulipa*). Station 5111, 16½ fathoms, sand, mud, and broken shells; shrimp and lancelets (*Branchiostoma lanceolatum*).

Fishing.—No fish were taken until a depth of 25 fathoms had been reached. From there to the inner end of the line nine groupers and two red snappers were secured. The first fish, six groupers (three red and three black), were captured on the morning of March 21 (trial 19) while the schooner was drifting in about latitude 26° 18′ N., longitude 83° 05′ W., depth 25 fathoms. They averaged 27 inches in length.

The largest fish taken during the cruise, a red grouper, weighing 31 pounds and measuring 43 inches in length, was caught at station 5109 (trial 20), 24 fathoms. Soon afterwards another red grouper, 31 inches long, was taken in a depth of 23 fathoms, while the schooner was under way. The last catch on this line was at the innermost station, No. 5111 (trial 22), depth 16½ fathoms, where the following were secured, namely: Two red snappers, averaging 31½ inches in length, and one red grouper, 29 inches long.

The trials on this line were made with great thoroughness and with the usual fresh bait, but the fish seemed to be scarce, although good spots might be found by working around over the ground in all directions. As a rule, more fish were found on the inshore ends of the line as the *Grampus* worked northward. Two small sharks (*Carcharhinus*) were taken at station 5107, and one half-dead sailors' choice (*Lagodon rhomboides*) was caught in a dip-net while at anchor during March 19.

LINE I.—MARCH 22 AND 23; STATIONS 5112 TO 5118.

Dredgings.—Line I was carried from shallow to deep water along a nearly straight course in 26° 28′ to 26° 31′ 50″ N. latitude. Seven dredgings were made, as follows: Station 5112, 16½ fathoms, fine white sand with black specks, gravel, one small fish (*Gillellus semicinctus*), annelids, and the following mollusks: *Crassatella floridana*, *Tellina antoni*, *Semele reticulata*, *Cavolina uncinata*, *Koonsia obesa*. Station 5113, 21 fathoms, gray sand, gravel, broken shells, shrimps and small crabs (*Neptunus spinicarpus*). Copepods, ctenophores and salpæ were taken in the surface net. Station 5114, 24 fathoms, coarse black sand, broken shells, one small starfish, crab, annelid, and sponge. Station 5115, 27½ fathoms, gray sand with black specks, broken shells, one eel (*Letharchus velifer*), and three species of crabs (*Lambrus agonus*, *Cryptopodia concava*, *Carpoporus papulosus*). Station 5116, 33 fathoms, gray sand and broken shells, sponges, and small crabs (*Podochela gracilipes*, *Lambrus agonus*). Station 5117, 37½ fathoms, hard gray sand, algæ, ascidians, shrimp, crabs (*Podochela gracilipes*, *Arachnopsis filipes*), and two small fishes (*Synodus fœtens*, *Aphoristia plagiusa*). Station 5118, 59 fathoms, hard fine sand and broken shells, three small shrimp, one crab, coral, and free crinoids (*Antedon*).

Fishing.—Only two successful trials were had on this line, although the weather was fine, and everything favorable for fishing. The first fish, a black grouper measuring 31½ inches long, was taken at 3 p. m., March 22, in 22 fathoms, sandy bottom. The second lot was secured about 6 p. m. of the same day, at station 5114 (trial 24) in

a depth of 24 fathoms. It consisted of two red snappers and fourteen groupers (four red and ten black), the former averaging 29, the latter 34 inches in length. The fish were very gamy and caught at the leads as well as at the baited hooks as soon as they touched bottom. Fishing was continued here about thirty minutes. No bites were felt along the remainder of the line.

LINE J.—MARCH 23 TO 27; STATIONS 5119 TO 5124.

Dredgings.—Six dredgings were made along an irregular line in latitude 26° 37′ to latitude 26° 45′ N., extending from deep water to shallow water, as follows: Station 5119, 45 fathoms, coral, sand, and broken shells, algæ, crinoids (*Antedon*), small crabs (*Carpoporus papulosus*), ascidians, mollusks (*Cardium peramabilis*, *Dentalium laqueatum*), and one small fish. Station 5120, 36 fathoms, fine sand, gravel, and broken shells, one ophiuran and two crabs (*Platylambrus serratus*). Station 5121, 31 fathoms, coarse sand and corals. Station 5122, 28 fathoms, sand with black specks, broken shells, one small crab, and a starfish. The surface net was towed in the same vicinity, securing copepods, medusæ, fish eggs, etc. Station 5123, 25½ fathoms, gray sandy mud, broken shells. Station 5124, 19 fathoms, fine gray sand with black specks, and a single small crab.

Fishing.—No success attended the trials for fish along this line and no traces were found of either red snappers or groupers. At 2:45 p. m., on March 27, however, while on the way from the last station of the line, No. 5124, to Tampa, Florida, in about latitude 26° 52′ N., depth 18 fathoms, both red snappers and groupers were observed in abundance.

Near station 5119, a female spotted porpoise (*Prodelphinus plagiodon*) was harpooned from a school of six that was playing about the vessel. She measured 7 feet in length and 3 feet 7 inches in circumference behind the pectorals. Her udders were full of milk, and she was accompanied by one young individual about half the size of the mother. Fragments of squids were found in her stomach. The skin and skeleton were prepared and sent to Washington. Two sharp-nosed skates were also taken at station 5122.

VISIT TO TAMPA BAY AND RETURN TO KEY WEST.

During March 28 the *Grampus* was under way bound to Tampa. In the morning many large schools of young herring were seen, pursued by about a dozen porpoises. One kingfish (*Scomberomorus*) was caught in the afternoon, and at night the schooner made Egmont light. She entered Tampa Bay the next day, and anchored off Gadsden's Point, about 5 miles below Port Tampa, where she was joined by Dr. Henshall.

April 3, the seine was hauled on Gadsden's Point and the following fish were obtained: Angel fish (*Chætodipterus faber*), mullet (*Mugil curema*), including the young about an inch long, gar fish (*Tylosurus marinus*), sailors' choice (*Lagodon rhomboides*), half beaks (*Hemirhamphus unifasciatus*), cyprinodonts, etc.

April 4, the *Grampus* returned to Egmont Key, where a large number of small herring and a few other fish were seined on the shore. In leaving Tampa Bay, two large devil-fish (*Manta birostris*) and two flying fish were observed. The Tortugas were reached on the 7th and the schooner remained there until the 9th, during which time the seine was hauled several times on Garden Key and Bird Key. At the former

place the following material was obtained: Barracudas (*Sphyræna picuda*), bone fish (*Albula vulpes*), cock-eyed pilot (*Glyphidodon saxatilis*), striped grunts (*Hæmulon elegans*), and several species of small fish belonging mostly to the Serranidæ. The catch at Bird Key comprised a trunk fish (*Ostracion trigonum*), several small fish, crabs, annelids, ophiurans, sea urchins, shrimp, and specimens of octopus. Jelly fishes, tunicates, holothurians, and aplysia were taken in the moat.

The *Grampus* arrived at Key West April 10, and left there for New York on the 15th.

SUMMARY OF THE WORK.

The information that we possessed respecting the red-snapper and grouper fishing grounds of the Gulf of Mexico prior to the investigation of the schooner *Grampus* has been summarized in a report by Capt. J. W. Collins,* from which we take the following extracts:

The grounds which are now generally visited in winter, and consequently of the greatest importance, are embraced in a somewhat narrow belt along what is termed the outer edge of the shore soundings, between the meridians of 85° and 88° west longitude [Northwestern Florida]. Along this stretch of sea bottom, which is more or less crescent-shaped, are various patches of considerable extent, with depths varying from about 20 to 47 fathoms, where the red snapper occurs in greater abundance during the winter season than elsewhere, so far as is known. The species is found to the southward and eastward of this, even so far as the Tortugas, and sometimes the fish are plentiful and bite freely, though, according to Stearns, there is this difference between the grounds east of the eighty-fifth meridian and those west of it: On the former, groupers are far more abundant than red snappers, outnumbering them at least two to one, while on the western grounds the case is reversed, for there the snappers are found in large schools, and average about twice as many in numbers as other species. The success of the Pensacola snapper fishery is unquestionably due, in a great measure, to the fact that this species has been found in such large schools on the western grounds and within easy reach of a market.†

The grounds lying between Cape San Blas and the Tortugas have been worked over, we are told, but mostly inshore, in from 5 to 15 fathoms, which region has been thoroughly fished by the Key West smackmen. Outside of the 15-fathom line, south of Tampa Bay, it is altogether probable that little fishing has been done, and here, as well as farther northwest, the red snapper may probably be found in abundance. * * * Although it is now [1885] deemed impracticable to go farther from Pensacola than the vessels have been in the habit of fishing, there is no doubt but that the men would extend their cruises were they sure of fair returns on distant grounds, whenever the supply of fish on those now visited grows less."

The region examined by the *Grampus* is the one described by Captain Collins as being most distant from Pensacola and the least known, but at the same time it is nearest Key West. It comprises the southern part of the submerged continental plateau off the western coast of Florida, between the depths of 15 and 50 fathoms. The plateau has there an average width of about 150 miles inside of the 100-fathom curve, from which line the depths increase rapidly toward the west. The area surveyed lies about

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* Report on the Discovery and Investigation of Fishing Grounds, made by the Fish Commission steamer *Albatross* during a cruise along the Atlantic coast and in the Gulf of Mexico; with notes on the Gulf fisheries. By Capt. J. W. Collins. Report U. S. Commissioner of Fish and Fisheries for 1885 (1887), pp. 217–305.

† The researches made by the *Albatross* between Tampa Bay and Tortugas [in 1885] apparently proved that red snappers were even more abundant in this region, in 25 to 27 fathoms, than they are farther to the northwest, and while the grouper appeared to outnumber the snapper north of Tampa, or between it and Cape San Blas, the reverse was the case on the more southern grounds.

midway between the coast and the 100-fathom curve, and has an average width of about 70 miles, nearly one-half that of the plateau itself.

The present survey can only be regarded as preliminary in its nature and results, indicating the principal resources of the new fishing grounds and proving their great value from an economical standpoint. Owing to the shortness of the season, the *Grampus* was obliged to work along straight courses, not deviating to one side or the other, even when it was apparent that the fishing spots encountered would yield suitable returns if carefully followed out. Good fishing was found in a number of places, but it is probable that had the fishing trials been continued longer, and the weather been more suitable at all times, the location of many additional fishing spots could have been definitely determined.

The total number of fish of each of the principal kinds taken was as follows: Red snappers, eighty-eight; red groupers, twenty-eight; black groupers, twenty-five; or about one and three-fifths times as many red snappers as groupers, indicating that the grounds are richest in the first-mentioned species, which is also the most highly prized for food. The red snappers were found in all depths from 15 to 48 fathoms, but the largest catches, one of thirty-one, the other of thirty-two fish, were made in depths of 15 and 25 fathoms. Three red snappers only were taken between 30 and 40 fathoms, and five between 40 and 48 fathoms, but this can not yet be taken as evidence that the red snapper does not occur abundantly in the deeper parts of the area examined. The range of these fish in weight was from 5 to 20 pounds.

The red grouper was found in depths of 15 to 37 fathoms, but only once in a greater depth than 26 fathoms. The largest catch, nine fish, was secured in 19½ fathoms. This species was taken at thirteen different stations, often in connection with either the red snapper or the black grouper, and sometimes with both. The black grouper was caught at only nine stations, in depths of 19½ to 48 fathoms, nineteen individuals being from between 19½ and 25 fathoms, and six from between 38 and 48 fathoms. Ten individuals, being the largest number taken at any one place, were obtained from a depth of 24 fathoms. The weight of the red groupers was from 5 to 31 pounds, and of the black groupers from 10 to 23 pounds.

The results obtained on each of the lines may be summarized as follows: *

Line A.—The bottom along this line consisted chiefly of white mud, sand, and broken shells and corals. The fish were found principally on bottoms of broken shells. The catch consisted of thirty-nine red snappers, three red groupers, three black groupers, and one grouper the species of which was not determined. All of these fish were taken in depths of 18 to 38 fathoms. At station 5053, thirty-one red-snappers and three groupers were caught in about twenty-five minutes by the use of six hand lines.

Line B.—The bottom on line B, where tested, was composed mostly of broken shells, with sand, some gravel, etc., and not much life was brought up in the dredge. Fish were taken at only two places, one red snapper in 36 fathoms, and three red snappers and twelve groupers in 19½ fathoms. Concerning both this line and line A, Captain Adams is of the opinion that, had he been searching for fish only, he could have found an abundance of both red snappers and groupers in a number of places by sounding for hard bottom.

Line C.—The bottom consisted chiefly of broken shells, but there was also considera-

* See also tables of dredging stations and fishing trials, pp. 311–312.

ble gray sandy mud, fine sand, broken coral, etc. The weather was stormy and the water rough most of the time, which greatly interfered with the operations of dredging and fishing. The bottom appeared to be rich in the lower forms of life at only two dredging stations. No red snappers or groupers were taken, although the bottom appeared to be favorable to them. This may have been due in part, however, to the rapidity with which the vessel drifted before the wind, not allowing the bait to remain long in one place.

Line D.—The bottom resembled that of the previous line, but had a larger proportion of broken shells and less mud. Fishing was carried on continuously, but only one red snapper was caught, in a depth of 25 fathoms. Two black groupers were hauled up to the surface from 39 fathoms, but escaped from the hooks.

Line E.—Broken shells composed the bottom in greater part, but hard sandy bottoms and muddy bottoms were found occasionally. Fish were taken only at the inner station, in 15 fathoms, where thirty-two red snappers and two red groupers were secured. While making this line, the sea was so rough that no fishing could be done except at the dredging stations. Even a moderate wind in this region produces a heavy chop sea, which interferes with the handling of the lines while the vessel is drifting.

Line F.—The bottom consisted chiefly of broken shells, with patches of gravel, sand, and sandy mud. Very few animals were taken in the dredge. During most of the time while fishing was being carried on the wind was light and favorable. Fish were obtained at five different places, in depths of 19 to 48 fathoms, namely, ten red snappers, one red grouper, and three black groupers. In 40 fathoms the fish seemed to be abundant, but did not bite well. They could be felt striking the lead or tugging feebly at the bait.

Line G.—Broken shells predominated along most of this line, mixed with gravel, sand, and mud. A stiff breeze prevailed during the entire time, interfering more or less with the fishing trials. The only fish obtained were three groupers, one at each of three stations, in depths of 18, 21½, and 26 fathoms.

Line H.—The bottom was composed of broken shells, sand, and mud. The wind was unfavorable for fishing on the outer or deep-water end of the line, but nearly died away while the vessel was on the inner end, where all of the fish taken were secured. The total catch consisted of two red snappers, six red groupers, and three black groupers from depths of 16½ to 25 fathoms. The largest catch was of three red and three black groupers in a depth of 25 fathoms.

Line I.—The bottom consisted of broken shells and hard and soft sand, and the weather was favorable for fishing. Fish were only taken, however, in depths of 22 and 24 fathoms, as follows, namely, two red snappers, four red groupers, and eleven black groupers.

Line J.—The bottom was composed of sand, broken shells, and mud. The weather was boisterous and no fish were caught.

General distribution of the fish.—On the more southern lines the red snappers and groupers were found as far out as depths of 35 to 40 fathoms, becoming less abundant but averaging larger in size as the water deepened. As the work progressed northward, the fish were chiefly obtained on the inner parts of the lines, the red grouper also taking the place of the red snapper, which was rarely seen. In the deeper water the black groupers predominated over the red groupers, the latter becoming relatively more common as the water shoaled toward the coast.

Food of the fish.—Care was taken to examine the stomachs of all of the red snappers and groupers obtained in order to determine, if possible, from their food the character of bottom which they might be expected to resort to most frequently, but they were in the habit of ejecting their food while being hauled in, and their stomachs were generally empty. The little material that was secured from this source consisted of several varieties of fish, including the flying fish, eels, crabs (*Calappa*), and mantis shrimp (*Squilla*), all of which may be regarded as active animals that could rarely be taken in the dredge. The ovaries of the females were in no cases much developed.

LISTS OF THE BRACHYURA, MOLLUSCA, AND FISHES COLLECTED.

By W. C. Kendall.

THE BRACHYURA.

Leptopodia sagittaria (Fabr.).

Stations 5072, 5088, 5099; $21\frac{1}{2}$ to 34 fathoms; three specimens, all ♂.

Podochela gracilipes Stimpson.

Stations 5055, 5073, 5078, 5102, 5106, 5117; 32 to 38 fathoms; one to four specimens at each station.

Metoporhaphis, sp. nov. (?).

Marco, one specimen, ♀.

Arachnopsis filipes Stimpson.

Stations 5072, 5076, 5078, 5104, 5117; 30 to 51 fathoms; one specimen at each station.

Libinia dubia Milne-Edwards.

Card's Sound (2 ♀), and Little Gasparilla (1 ♂).

Libinia emarginata (Say), var. (?).

Charlotte Harbor, 1 ♀.

Epialtus dilatatus A. M.-Edwards (?).

Bird Key, 1 ♀.

Pericera cornuta (Herbst) (?).

Station 5110, 21 fathoms, 1 ♂.

Pericera, sp.

Station 5063, 27 fathoms, one specimen.

Mithrax (?), sp.

Station 5108, 27 fathoms, 1 young ♂.

Microphrys bicornutus (Latreille).

Bird Key, 3 ♂, 6 ♀.

Mithraculus sculptus (Lamarck.).

Bird Key; 13 ♂, 18 ♀.

Lambrus agonus Stimpson.

Stations 5053, 5076, 5078, 5079, 5102, 5104, 5107, 5115, 5116; 25 to 51 fathoms; one to two specimens at each station.

Lambrus fraterculus Stimpson (?).

Stations 5057, 5078, 5089, 5104, 5108; 27 to 51 fathoms; one specimen at each station.

Platylambrus serratus M.-Edwards.

Station 5122, 28 fathoms, 1 ♂.

Platylambrus (?), sp.

Stations 5098, 5109; 18 to 24 fathoms; 2 specimens.

Cryptopodia concava Stimpson.

Stations 5101, 5115; 27 to 30 fathoms; 1 ♂, 1 ♀.

Menippe mercenaria (Say).

Key West, 1 ♂.

Carpoporus papulosus Stimpson.

Stations 5104, 5115, 5119; 27½ to 51 fathoms; four specimens.

Leptodius floridanus Gibbes.

Bird Key, 2 ♂.

Panopeus herbstii Milne-Edwards.

Tampa Bay, 1 ♂.

Panopeus packardii Kingsley.

Card's Sound, 3 ♂, 2 ♀.

Neptunus gibbesii (Stimpson).

Egmont Key, Tampa Bay, 1 ♀.

Neptunus anceps (Saus.) A. M.-Edwards.

Bird Key, 1 ♂, 2 ♀.

Neptunus spinicarpus (Stimpson) A. M.-Edwards.

Stations 5054, 5081, 5088, 5095, 5106, 5107, 5108, 5113; 20 to 36 fathoms; one to two specimens at each station.

Callinectes hastatus Ordway.

Taken at the following localities on the west coast of Florida, namely: Card's Sound, Marco, Stump Pass, Little Gasparilla Pass, Big Gasparilla, Myakka River, Gordon's Pass, Cape Sable Creek, Punta Gorda.

Callinectes ornatus Ordway.

Bird Key, 1 ♂; Key West, 6 ♂, 5 ♀.

Acheloüs spinimanus (Latr.).

Key West, 3 ♂; Gordon Pass, 1 ♂.

Acheloüs depressifrons Stimpson.

Bird Key, 2 ♂, 2 ♀.

Acheloüs, sp.

Station 5108, 27 fathoms, one specimen.

Gelasimus pugilator (Bosc) Latr.

Card's Sound, Marco, Big Gasparilla, Cape Sable Creek; many specimens.

Gelasimus pugnax Smith.

Card's Sound, 3 ♂, 1 ♀.

Ocypoda arenaria (Catesby).

Key West, 1 ♂; Marquesas Key, 2 ♂; Loggerhead Key, 2 ♂; Little Gasparilla Pass, 1 ♂.

Pachygrapsus transversus Gibbes.

Bird Key, 4 ♂, 2 ♀.

Sesarma cinerea (Bosc).

Long-boat Key, 2 ♂, 1 ♀.

Sesarma angustipes Dana.

Long-boat Key, 5 ♂, 9 ♀; Little Gasparilla, 1 ♂; Big Gasparilla, 1 ♂.

Aratus pisoni Milne-Edwards.

Long-boat Key, 5 ♂, 8 ♀; Little Gasparilla Pass, 1 ♂.

Geocarcinus lateralis Guerin.

Loggerhead Key, 5 ♂, 1 ♀.

Calappa marmorata Boyd.

Three and one-half miles west of station 5052, 1 ♂.

Calappa, sp.

A male from station 5076 is too young to be identified.

Cyclois bairdii Stimpson (?)

One small crab, a male, from station 5099, 21½ fathoms, appears to agree in all particulars with Stimpson's types of *Cyclois bairdii*, from Cape St. Lucas, with which it has been carefully compared. The Florida example is slightly smaller than the smallest of Dr. Stimpson's specimens, and if any appreciable difference exists between the Gulf and the Pacific forms it can not be made out with the material at hand. In Dr. Stimpson's description (Notes on N. A. Crust., Ann. Lyc. Nat. Hist., N. Y., VII, p. 237, 1862) it is stated that the front of *Cyclois bairdii* is tridentate, but in his types, which are preserved in the National Museum, as well as in our specimen, the front is always prominently bidentate.

Iliacantha subglobosa Stimpson.

Station 5104, 51 fathoms, 1 ♂.

Iliacantha sparsa Stimpson.

Station 5077, 33 fathoms, 1 ♂.

Callidactylus asper Stimpson.

Stations 5088, 5102, 32 to 34 fathoms, 1 ♂, 1 ♀.

Prionoplax atlanticus, n. sp.

Carapax wide, nearly straight transversely, strongly convex longitudinally; lateral borders straight. Unlike *P. spinicarpus* Milne-Edwards, which has its surface finely granulated and marked by straight deep channels, the surface of our specimen is smooth, shiny, and has no channels marking off the areolations. Front lamellate, advanced, sloping and divided into two rounded lobes by a slight notch, which in *P. spinicarpus* continues behind with the mesogastric groove. Antero-lateral borders armed with three flat, sharp teeth, one of which is at the external orbital angle, instead of four as in *spinicarpus;* orbits large, directed forward. Eyestalks not inflated at base as in *P. spinicarpus;* cornea large. Antennules well developed, folded back transversely in a little groove, concealed for the most part behind the front and separated by a straight nasal lobe. The antennæ are in the notch between the front and the suborbital border, their bases small and almost cylindrical; they touch the front at the internal angle. The next segments are small and cylindrical. Epistome wide but very short, and limited behind by a very prominent labial border; from each side it continues with a channel which follows the line of the branchiostegal suture.

Chelipeds moderate, smooth; meros armed with a small tooth on the superior margin; carpus armed with one small tooth on the superior border and another external inferior tooth near the hand. The superior tooth is the largest. Hand naked, finger slightly inflected. Ambulatory legs somewhat flattened, long, slender. Penultimate pair the longest. No joints of the abdomen soldered together.

Of this species, which is believed to be new, one male was taken at station 5069, 23 fathoms.

Ethusa, sp.

Stations 5055, 5057, 5106.

Cymopolia, sp.

Stations 5072, 5078, 5085, 5101, 5106, 5108, and also at Marquesas Key.

THE MOLLUSCA.*

PELECYPODA.

Lima squamosa Lamarck.

Bird Key, Tortugas.

Arca noæ Linné.

Key West, and station 5098, 18 fathoms.

Crassatella floridana Dall.

Station 5112, 16½ fathoms.

Lucina crenulata Conrad.

Station 5099, 21½ fathoms.

Chama congregata Conrad.

Station 5099, 21½ fathoms.

Cardium peramabilis Dall.

Station 5119, 45 fathoms.

Liocardium lævigatum Linné.

Station 5080, 25 fathoms; 5099, 21½ fathoms.

Venus pygmæa Lamarck.

Station 5099, 21½ fathoms.

Tellina antoni Phil. (=**interrupta** Wood var.).

Station 5068, 17 fathoms; 5112, 16½ fathoms.

Semele cancellata Orbigny.

Station 5084, 19 fathoms.

Semele reticulata Gmelin.

Station 5112, 16½ fathoms.

Corbula dietziana C. B. Adams.

Station 5080, 25 fathoms.

Spengleria rostrata Spengler.

Bird Key, Tortugas.

SCAPHOPODA.

Dentalium matara Dall.

Station 5109, 24 fathoms.

Dentalium laqueatum Verrill.

Station 5119, 45 fathoms.

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* In the identification of the Mollusca Mr. Kendall has been assisted by Mr. W. H. Dall, of the U. S. National Museum.

PTEROPODA.

Cavolina uncinata Rang.
Station 5112, surface.

GASTROPODA.

Aplysia wilcoxii Heilprin.
West coast of Florida.

Koonsia obesa Verrill.
Station 5112, 16½ fathoms.

Oliva literata Lamarck.
Stations 5080, 5081, 5085; 20 to 25 fathoms.

Fasciolaria tulipa Linné.
Station 5110, 21 fathoms; Marquesas Key, Key West.

Fusus eucosmius Dall.
Station 5077, 33 fathoms; station 5102, 32 fathoms.

Nassa ambigua Montagu.
Station 5077, 33 fathoms; 5080, 25 fathoms.

Murex chrysostoma Gray.
Station 5085, 24 fathoms.

Ocinebra nucea Mörch (=**cellulosa** Conrad).
Station 5085, 24 fathoms.

Muricidea floridana (Conrad) Dall.
Station 5076, 39 fathoms; 5108, 27 fathoms.

Distortrix reticulata Link.
Station 5109, 24 fathoms.

Cerithium muscarum Say.
Card's Sound.

Turritella acropora Dall.
Stations 5084, 5107, 5108; 19 to 31 fathoms.

Crepidula convexa Say.
Station 5098, 18 fathoms.

Crepidula unguiformis Lamarck.
Key West.

Natica canrena Lamarck.
Station 5083, 15 fathoms; Garden Key, Tortugas.

Polynices lactea Guilding.
Station 5080, 25 fathoms; 5098, 18 fathoms.

Turbo crenulatus Gmelin.
Station 5107, 31 fathoms; 5108, 27 fathoms.

Turbo (Astralium) imbricatum Gmelin.
Marquesas Key.

Acanthochiton astriger Reeve.
Bird Key, Tortugas.

THE FISHES.

Branchiostoma lanceolatum (Pallas).

Stations 5064, 5066, 5068, 5111; 16½ to 24 fathoms.

Carcharhinus terræ-novæ (Richardson).

Several places on the fishing grounds, surface.

Reniceps tiburo Gill.

Charlotte Harbor.

Synodus fœtens (Linné).

Station 5117, 59 fathoms, one young specimen.

Ophichthys punctifer (Kaup) (?).

Station 5095, 20½ fathoms; the specimen could not be identified with certainty on account of its small size.

Letharchus velifer Goode and Bean.

Station 5115, 27½ fathoms. The single specimen obtained is small.

Sphagebranchus kendalli Gilbert, sp. nov. (see p. 310).

Station 5080, 25 fathoms.

Tylosurus marinus (Bl. Schn.).

Lacosta Island, Charlotte Harbor; Gadsden's Point, Tampa Bay.

Hemirhamphus unifasciatus (Ranzani).

Gadsden's Point, Tampa Bay.

Albula vulpes Linné.

Garden Key, Tortugas.

Exocœtus noveboracensis Mitchill (?).

At many places on the fishing grounds, at the surface.

Hippocampus hudsonius DeKay.

Station 5106, 36 fathoms.

Mugil curema C. & V.

Gadsden's Point, Tampa Bay.

Sphyræna picuda Bl. Schn.

Garden Key, Tortugas.

Scomberomorus regalis (Bloch).

Near Egmont Key.

Auxis thazard Lac.

Several places on the red-snapper grounds.

Nomeus gronovii Gmelin.

Taken from under *Physalia* on several occasions.

Stromateus paru Linné.

Surface; swimming freely and from under *Physalia*.

Epinephelus morio C. & V.

Red Grouper. Taken on the offshore fishing grounds in depths of 15 to 37 fathoms, but only once in a greater depth than 26 fathoms. The weight of the specimens obtained ranged from 5 to 31 pounds each.

Epinephelus nigritus (Holbrook).

Black Grouper. Taken on the offshore fishing grounds in depths of 19½ to 48 fathoms; nineteen specimens were from between 19½ and 25 fathoms, and six from between 38 and 48 fathoms. They ranged in weight from 10 to 23 pounds each.

Serranus formosus Linné.

Two specimens; caught in entrance to Charlotte Harbor, March 9. Also taken at night, 3½ miles west of station 5052, and at station 5097, 12 fathoms.

Prionodes (?) sp.

One young example from station 5119.

Rhypticus pituitosus Goode and Bean.

Station 5061, 36 fathoms.

Lutjanus blackfordi Goode and Bean.

Red-snapper. Taken on the offshore grounds in all depths from 15 to 48 fathoms. The range in weight of individuals was from 5 to 20 pounds.

Orthopristis chrysopterus Linné.

Lacosta Island, Charlotte Harbor, and in the channel from Charlotte Harbor.

Hæmulon rimator Jordan & Swain.

Taken at night 3½ miles west of station 5052.

Hæmulon sciurus Shaw.

Garden Key, Tortugas.

Sparus pagrus Linné.

Red-snapper grounds.

Calamus milneri Goode and Bean.

Lacosta Island, Charlotte Harbor.

Lagodon rhomboides Linné.

Lacosta Island, Charlotte Harbor; Gadsden's Point, Tampa Bay; and taken at night 3½ miles west of station 5052.

Sciæna ocellata Linné.

Lacosta Island, Charlotte Harbor.

Chætodipterus faber Broussonet.

Gadsden's Point, Tampa Bay.

Glyphidodon saxatilis Linné.

Garden Key, Tortugas.

Prionotus scitulus Jordan and Gilbert.

Lacosta Island, Charlotte Harbor.

Gillellus semicinctus Gilbert.

Station 5108, 31 fathoms; 5112, 16½ fathoms.

Dormitator (?), sp.

Station 5057, 37 fathoms. A single specimen, 1⅓ inches long.

Bregmaceros atlanticus Goode & Bean.

Station 5069, 23 fathoms; 5109, 24 fathoms.

Ophidium sp.

Station 5099, 21½ fathoms.

Citharichthys macrops Dresel.

Lacosta Island, Charlotte Harbor.

Aphoristia plagiusa Linné.

Station 5117, 37½ fathoms.

Antennarius, sp.

Station 5089, 38 fathoms.

Ostracion quadricornis Linné.

From stomach of black grouper on two occasions.

Ostracion trigonum Linné.

Bird Key, Tortugas.

Monacanthus hispidus Linné.

From stomach of sharp-nosed shark.

Tetrodon testudineus Linné.

Lacosta Island, Charlotte Harbor.

DESCRIPTION OF A NEW SPECIES OF EEL (SPHAGEBRANCHUS KENDALLI).

By Charles H. Gilbert.

Body much more elongate than in *selachops*. Snout very slender, nearly terete, projecting beyond mouth for a distance equaling two-thirds length of gape. Eye larger than usual in this genus, its diameter half length of snout, equaling interorbital width; its anterior margin slightly behind front of lower jaw. Gape 4 in head. Teeth in a single series in both jaws, acute, somewhat compressed, directed backwards. Teeth on head of vomer well developed, in a $\wedge$-shaped patch. No teeth on shaft of vomer in the single type specimen; this probably abnormal.

Anterior nostrils in a short tube, well forward on lower side of snout; posterior pair without tube, labial.

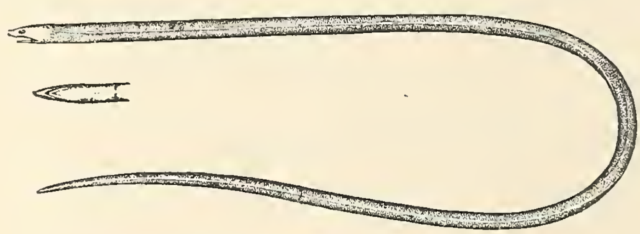
Gill openings very small, their width about equaling diameter of eye, separated by a distance equaling half their width. The slits wholly transverse in direction, not diverging posteriorly as in *selachops*.

Head much shorter than in *selachops*, the trunk somewhat longer; head $7\frac{3}{4}$ in length anterior to vent; body $1\frac{1}{4}$ in tail. (In *selachops*, head less than 5 in body; body $1\frac{1}{2}$ in tail.)

Color nearly uniform olivaceous, lighter below.

A single specimen 6.75 inches long was taken by the U. S. Fish Commission schooner *Grampus* in 25 fathoms off the coast of Florida, latitude 25° 34′ N., longitude 82° 50′ W. (station 5080).

The species is named in honor of Mr. W. C. Kendall, naturalist of the *Grampus* at the time the fish was taken.



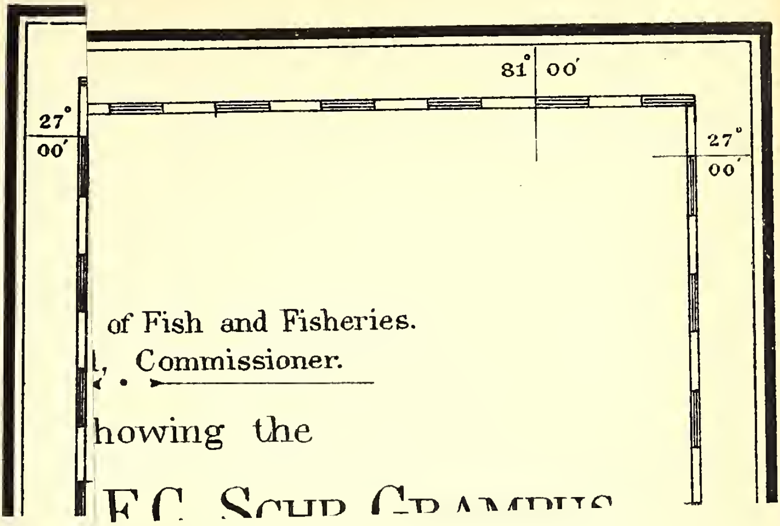
Sphagebranchus Kendalli Gilbert (natural size).

Record of dredgings made by the Fish Commission schooner Grampus on the Red Snapper Grounds off the west coast of Florida, February and March, 1889.

Line.	Station No.	Date.	Hour.	Position. Lat. N.	Position. Long. W.	Depth (faths.)	Nature of bottom.	Temperature. Air.	Temperature. Surface.	Temperature. Bottom.	Drift. Direction.	Drift. Miles.
		1889.		° ′ ″	° ′ ″			F.	F.	F.		
A....	5050	Feb. 15	8:30 a. m	25 01 00	82 22 00	15½	wh. m	71	65.5	66	W. by N.	½
	5051	15	12:45 p. m	25 00 31	82 32 00	18	brk. Sh	73	67	67	S.	¼
	5052	15	4:30 p. m	25 00 31	82 40 00	21	wh. m. brk. Sh	77	67	67	S.	⅛
	5053	16	7:40 a. m	25 00 31	82 51 40	25	Sandy M. Sh. Co. Sponges	71	68	68.5	NNE.	¼
	5054	16	10:40 a. m	25 00 31	83 03 00	29	Moderately hard, brk. Sh	75	69	68	SSW.	⅛
	5055	16	12:30 p. m	25 02 49	83 14 00	32	hrd. brk. Sh. and Co	73	68.5	68.5	SW.	⅛
	5056	16	3:20 p. m	25 02 49	83 25 00	36	S. brk. Sb	74	70	69.5	S.	⅛
	5057	17	6:15 a. m	25 02 00	83 34 00	37	S. Sh. Co	76	76	69.5	S. and NE.	¾
	5058	17	10:40 a. m	25 02 00	83 44 00	44½	S. brk. Sh	79	72	69.5	S.	1/10
B....	5059	17	1:30 p. m	25 12 00	83 46 00	50	S. brk Sh	79	70.5	70	NE.	⅛
	5060	17	3:30 p. m	25 12 00	83 36 00	38	S. brk. Sh. Co	76	71	69.5	NE.	⅜
	5061	18	6:15 a. m	25 12 00	83 20 30	36	S. Sh	70	70	68	NNW.	½
	5062	18	10:15 a. m	25 17 00	83 09 00	30½	S. blk. Sp. brk. Sh	76	69	70.5	ESE.	½
	5063	18	3:30 p. m	25 17 00	82 54 30	27	M. S. brk. Sh	77	70	67.5	NE.	⅛
	5064	19	6:10 a. m	25 17 00	82 49 15	24	soft M. S. brk. Sh	69	68	67	N.	⅛
	5065	19	10:00 a. m	25 15 00	82 39 15	19½	hrd. S. brk. Sh	77	69	67	E. by N.	1/10
	5066	19	12:30 p. m	25 13 00	82 28 00	17	G. brk. Sh	80	69.5	66	E.	1/10
	5067	19	3:45 p. m	25 13 00	82 17 00	14½	hrd. Sh. Co	83	70	66	E.	⅛
C....	5068	26	1:00 p. m	25 23 00	82 32 00	17	crs. G. brk. Co. Sh	70	66	65.5	W.	⅛
	5069	26	2:45 p. m	25 23 00	82 43 00	23	Soft Sandy M	69	66	66	W.	1/10
	5070	26	4:45 p. m	25 23 00	82 54 30	26½	hrd. S. brk. Sh	68	65.5	67	W.	1/10
	5071	28	7:55 a. m	25 24 30	83 06 00	30	fne. gy. S. bk. Sp	69	67	69	W.	1/10
	5072	28	9:50 a. m	25 23 30	83 17 00	33½	S. brk. Sh. Co. Soft	71	68.5	68.5	W.	1/10
	5073	28	11:35 a. m	25 23 00	83 28 00	38	S. brk. Sb. Co	71	72	69	W.	1/10
	5074	28	1:30 p. m	25 24 00	83 40 00	52	hrd	76	75	69	W.	1/10
D....	5075	28	3:10 p. m	25 34 00	83 39 30	52½	fne. gy. S. brk. Sh. and Co	74	70	70	NW.	1/10
	5076	Mar. 1	7:45 a. m	25 34 00	83 28 00	39	crs. gy. S. brk. Co. Sb	69	68	69	NW.	1/10
	5077	1	11:50 a. m	25 38 21	83 18 00	33	crs. gy. S. brk. Co. Sh	70	68	68.5	NW.	¼
	5078	1	3:30 p. m	25 34 00	83 07 00	30	fne. S. brk. Sh	71	68	68.5	NW.	1/10
	5079	2	9:00 a. m	25 34 30	83 01 00	27	hrd. S. bk. Sp	68	66.5	68	SW.	1/10
	5080	2	1:30 p. m	25 34 00	82 50 00	25	S. brk. Sh	72	66	67	NW.	⅛
	5081	3	6:00 a. m	25 33 30	82 39 00	20	fne. S. M	67	66	67	NW.	⅛
	5082	3	10:15 a. m	25 34 00	82 27 00	15½	gy. S. brk. Sh	71	67	67.5	NE.	1/10
E...	5083	10	1:00 p. m	25 44 32	82 26 15	15	G. brk. Sh. Co	68	66	66.5	SW.	1/10
	5084	10	5:20 p. m	25 44 32	82 37 15	19	S. brk. Sh. Nullipores	66	65	65.5	WSW.	1/10
	5085	11	6:15 a. m	25 44 32	82 48 15	24	fne. S. brk. Sh. Co	59	64	66.5	SW.	½
	5086	11	8:00 a. m	25 44 32	82 59 15	28	M. fne. S. brk. Sh	58	64	66	WSW.	1/10
	5087	11	9:30 a. m	25 44 32	83 10 15	31	fne. S. brk. Sh	56	70	68	WSW.	1/10
	5088	11	11:05 a. m	25 44 32	83 21 15	34	fne. S. brk. Sh	60	73	69	WSW.	1/10
	5089	11	12:40 p. m	25 40 00	83 32 00	38	fne S	60	73	68.5	WSW.	1/10
	5090	11	2:15 p. m	25 44 00	83 43 00	53	S. brk. Sh	58	69	68	WSW.	1/10
F....	5091	11	5:00 p. m	25 50 15	83 41 30	49	fne. S. brk. Sh	55	68	68	WSW.	1/10
	5092	15	8:25 a. m	25 54 00	83 20 00	31	gy. S. bk. sp. brk. Sh	66	70	69	ESE.	⅛
	5093	15	11:45 a. m	25 54 02	83 09 00	28	S. bk. Sp. brk. Sh. Co	70	70	69	ENE.	1/10
	5094	15	2:45 p. m	25 54 02	82 58 00	25	crs. G. brk. Sh. Co	75	65	67	E.	1/10
	5095	15	6:00 p. m	25 54 00	82 42 55	20½	gy. Sandy M	64	65	65.5	ESE.	1/10
	5096	16	3.00 p. m	25 54 00	82 29 00	16	gy. S. M	74	65	66.5	ESE.	1/10
G....	5097	17	11:00 a. m	26 11 00	82 27 00	12	fne. gy. S. brk. Sh	76	65	65	SSW.	1/10
	5098	17	2:00 p. m	26 07 30	82 38 00	18	hrd. S. brk. Sh	71.5	65	66	WNW.	1/10
	5099	17	4:40 p. m	26 04 00	82 49 00	21½	S. brk. Sh	65	66	66	W.	1/10
	5100	18	5:40 a. m	26 04 00	83 00 00	26	blk. G. M. brk. Sh	67	69	69	NW.	3/10
	5101	18	7:25 a. m	26 06 00	83 11 00	30	blk. G. M. brk. Sh	70	69.5	70	NW.	1/10
	5102	18	8:55 a. m	26 08 00	83 22 00	33	G. S. brk. Sh	72	69	69.5	NW.	1/10
	5103	18	10:35 a. m	26 09 00	83 33 00	36	fne. S	73	69	69.5	NW.	1/10
	5104	18	12:25 p. m	26 13 00	83 44 00	51	crs. S. brk. Co	75	68	69	NW.	1/10
H....	5105	18	2:30 p. m	26 20 00	83 45 00	56	S	77	68.5	67	NNE.	2/10
	5106	18	4:15 p. m	26 19 00	83 33 00	36	S	71	68.5	69.5	NNE.	2/10
	5107	18	5:45 p. m	26 19 00	83 22 00	31	S. brk. Sh	70	68	67.5	NNE.	2/10
	5108	21	6:15 a. m	26 19 00	83 11 00	27	S	63	65	68	SSW.	⅛
	5109	21	1:00 p. m	26 17 30	83 00 00	24	fne. gy. S. M. brk. Sh	68	71	67	E.	2/10
	5110	21	6:20 p. m	26 19 00	82 50 00	21	S. bk. Sp. brk. Sh	64	66	66	NE. by E.	2/10
	5111	22	8:50 a. m	26 20 00	82 39 00	16½	S. M	64	65	66	NNW.	2/10
I.....	5112	22	11:00 a. m	26 28 00	82 46 00	16½	fne. wh. S. bk. Sp	64	65	67.5	NNW.	2/10
	5113	22	1:50 p. m	26 29 00	82 57 00	21	gy. S. brk. Sh	67	65.5	66	NW. by W.	2/10
	5114	22	6:00 p. m	26 30 00	83 08 00	24	crs. bk. S. brk. Sh	67	65	66.5	SW.	1/10
	5115	23	7:45 a. m	26 30 00	83 19 00	27½	gy. S. brk. Sb	69	66	67.5	NW.	2/10
	5116	23	10:00 a. m	26 30 00	83 30 00	33	gy. S. brk. Sh	74	67	68	SW.	2/10
	5117	23	12:15 p. m	26 31 50	83 42 00	37½	hrd. gy. S	71	68	69	SW.	2/10
	5118	23	2:45 p. m	26 30 00	83 55 00	59	hrd. fne. S	69	68	69	NNW.	2/10
J....	5119	23	4:30 p. m	26 39 00	83 56 30	45	Co. S. fne. Sh	69	68	69	N. by W.	2/10
	5120	26	6:15 a. m	26 45 00	83 45 00	36	G. fne. S. brk. Sh	68	66	65.5	S.	2/10
	5121	26	8:30 a. m	26 43 00	83 34 00	31	Co. S	69	67	66	E.	2/10
	5122	26	11:05 a. m	26 39 38	83 23 00	28	S. bk. Sp. brk. Sh	68	66.5	66	E.	2/10
	5123	26	6:15 p. m	26 37 00	83 12 00	25½	gy. S. M. brk. Sh	64	68	66	ENE.	2/10
	5124	27	8:00 a. m	26 38 00	83 00 00	19	fne. gy. S. bk. Sp	63	66	65.5	N.	2/10

Record of the fishing trials at which red snappers and groupers were obtained.

Line.	Record number.	Dredging station number.	Date.	Hour.	Position.		Depth.	Nature of bottom.	Temperature.			Kind of fish taken.	Number taken.	Average size.		Remarks.
					Latitude N.	Longitude W.			Air.	Surface.	Bottom.			Length.	Weight.	
			1889.		° ′ ″	° ′ ″	Fath.		F.	F.	F.			Inches.	Pounds.	
A....	1	......	Feb. 15	1:15 p. m..	25 00 31	82 32 00	18	S. brk. Sh.....	73	67	67	Red snappers.....	4	....	....	
	2	5052	15	4:30 p. m..	25 00 31	82 40 00	21	M. fne. S	77	67	67	....do..............	2	27½	12	
	3	5053	16	7:40 a. m..	25 00 31	82 51 40	25	Hrd. Sh. Co. Sponges.	71	68	68.5	..do..........	31	24	9⅔	
												Groupers.........	3	....	16⅔	1 red grouper, 8 pounds; 2 black groupers, 20, 22½ pounds.
	4	......	16	5:30 p. m..	25 02 49	83 32 00	36	S. brk. Sh.....	......	......	......	Red snappers.....	2	34½	18	
												Groupers..........	1	35	20	
	5	......	16	Evening..	25 02 00	83 34 00	37	S. Co. Sh......	76	76	69.5	Red groupers.....	2	21	5½	At anchor.
	6	......	17	9 a. m. ..	25 02 00	83 37 00	38	S. Co. Sh......	......	......	......	Black groupers...	1	28	19	
B....	7	......	17	Evening..	25 12 00	83 20 30	36	S. Sh..........	70	70	68	Red snappers.....	1	28	15	Do.
	8	5065	19	10 a. m...	25 15 00	82 39 15	19½	Hrd. gy. S. Sh.	77	69	67	....do............	3	23⅔	8½	
												Groupers..........	12	23⅓	9	9 red groupers, 5 to 10 pounds; 3 black groupers, 10 to 17 pounds.
C....	......	......	....	....	....	....	......	....	......	......	......	....	......	....	....	No fish were taken on line C.
D....	9	5076	Mar. 1	7:45 a. m..	25 34 00	83 28 00	39	Crs. gy. S. Co Sh.	69	68	69	Black groupers...	2	....	....	
	10	5080	2	1:30 p. m..	25 34 00	82 50 00	25	S. brk. Sh.....	72	66	67	Red snappers.....	1	30	18	
E....	11	5083	10	1 p. m.....	25 44 32	82 26 15	15	Bk. G. brk. Sh Co.	68	66	66.5	...do...........	32	25	8⅔	
												Red groupers.....	2	27	9½	
F....	12	.....	12	a. m.......	25 52 00	83 31 00	40	Hrd	61	71	......	Red snappers.....	4	31½	18¼	
												Black groupers...	2	33	19	
				p. m								Red snappers.....	2	....	....	
	13	......	13	....	25 58 00	83 30 00	48	Hrd...........	66	68	......	...do..........	1	32	20	
												Black groupers...	1	38	23	
	14	5094	15	2:45 p. m..	25 54 00	82 58 00	25	Crs. S. brk. Sh Co.	75	65	67	Red snappers.....	3	24⅔	9⅓	
	15	...	16	....	25 54 00	82 40 00	19	Hrd..........	......	......	......	Red groupers.....	1	19	4½	
G....	16	5098	17	2 p. m. ..	26 07 00	82 38 00	18	Hrd S. brk. Sh	71.5	65	66	....do............	1	23½	6	
	17	5099	17	4:40 p. m..	26 04 00	82 49 00	21½	S. brk. Sh.....	65	66	66	... do...........	1	26	7	
	18	5100	18	5:40 a. m..	26 04 00	83 00 00	26	G. M. brk. Sh.	67	69	69	... do...........	1	26	7½	
H....	19	......	21	....	26 18 00	83 05 00	25	S	......	......	......	Groupers..........	6	27	11	3 red and 3 black groupers.
	20	5109	21	1 p. m. ...	26 17 00	83 00 00	24	Fne. S. M. brk. Sh.	68	71	67	Red groupers.....	1	43	31	
	21	......	21	....	26 18 00	82 58 00	23	Fne. S. M. brk. Sh.	......	......	......	....do............	1	31	11	
	22	5111	22	8:50 a. m..	26 20 00	82 39 00	16½	S. M..........	......	......	......	Red snappers.....	2	31½	17½	
												Red groupers.....	1	29	11	
I	23	......	22	....	26 29 00	83 00 00	22	Gy. S	......	......	......	Black groupers...	1	31⅓	16	
	24	5114	22	6 p. m.....	26 30 00	83 08 00	24	Crs. bk. S. brk. Sh.	67	65	66.5	Red snappers.....	2	29	12½	
												Groupers..........	14	34	14½	4 red and 10 black groupers.
J	......	......	....	....	....	....	......	....	......	......	......	....	......	....	....	No fish were taken on line J.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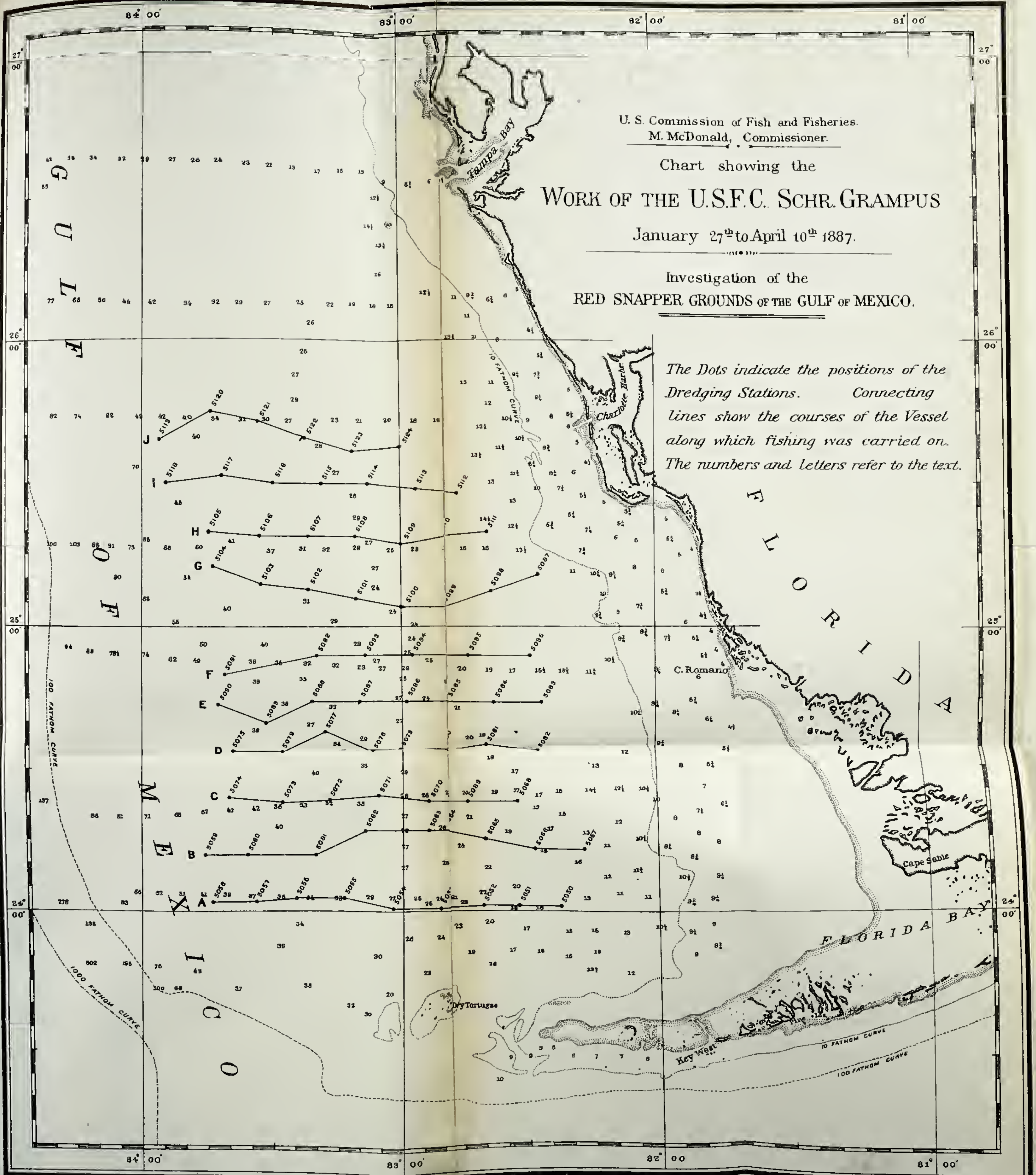

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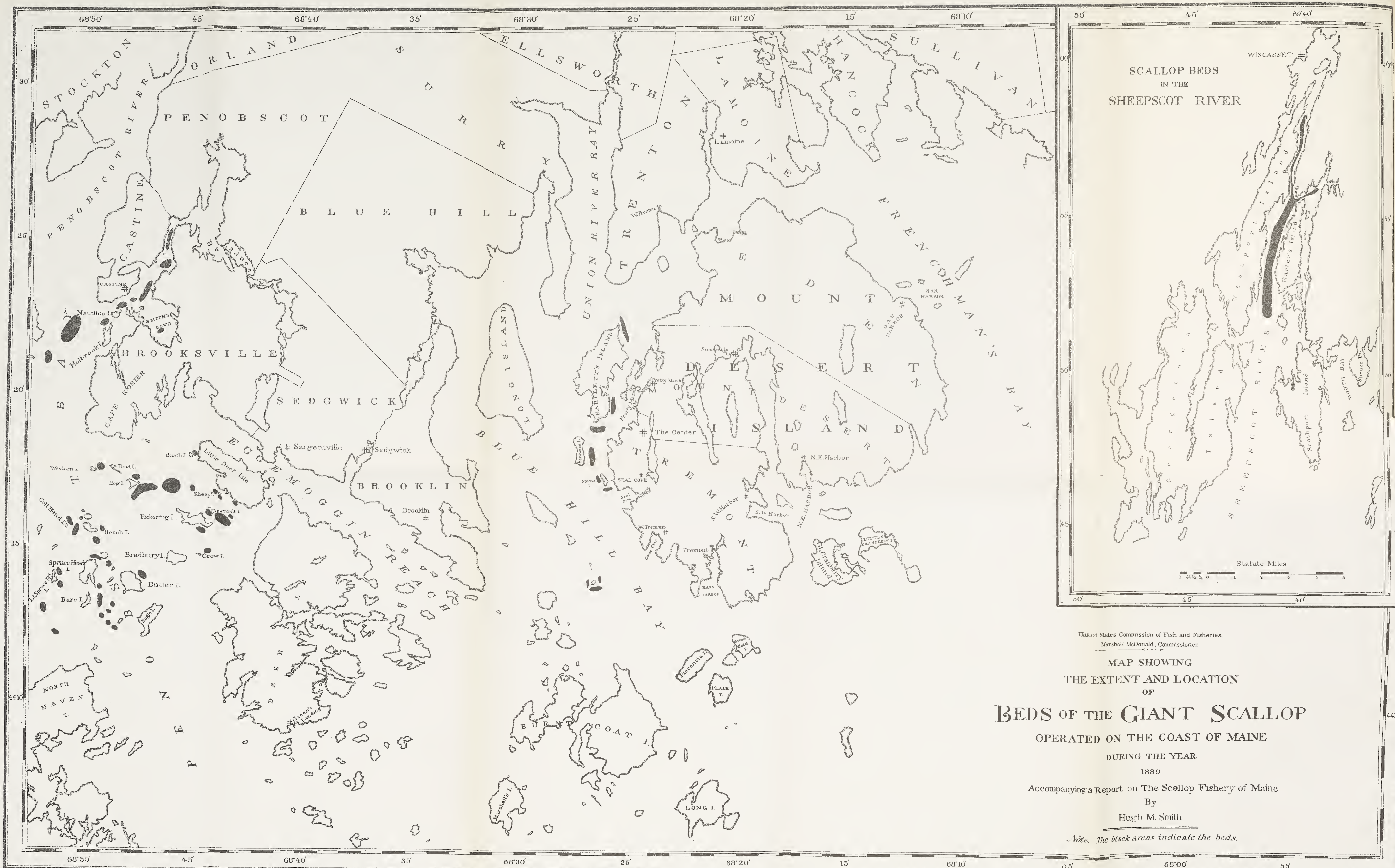

E.J.Rogers. Oct. '90.

68°50′ 45′

16.—THE GIANT SCALLOP FISHERY OF MAINE.

BY HUGH M. SMITH.

(With Plates CXII–CXVI.)

A.—INTRODUCTION.

The fishery for scallops on the coast of Maine is an industry of such comparatively recent inception that the general fishery interests, except those directly concerned, are, as a rule, misinformed of its extent and character, or wholly ignorant of its existence. Although the industry gives employment to several hundred persons; has considerable capital devoted to it; yields large quantities of a highly esteemed and valuable food product; and is capable of great improvement and development, it appears to have received little attention, and the first investigation of its nature and extent was undertaken by the U. S. Fish Commission in 1889.

As an illustration of the paucity of information on the subject, the writer would quote a well-known authority on mollusks. Speaking of the scallop which is the object of the fishery in Maine, Winslow says:

> The species is not abundant nor of commercial importance. It is available for food, however, and is occasionally used as such.*

This may be said to represent all that has been published on the giant scallop viewed from a commercial standpoint. At the time at which Winslow wrote, the foregoing statement was no doubt substantially correct. But conditions have changed; and it is the province of this paper to show that in many localities the species is very abundant and of great and growing economic value; and the fishery is thought to be of sufficient magnitude and importance to warrant the detailed discussion which follows.

The writer is indebted to the following-named persons for valuable data based on original observations on scallops and the scallop fishery adjacent to their homes: Messrs. L. F. Gott, of Tremont; F. W. Lunt, of West Tremont; W. W. A. Heath, of Seal Cove; S. D. Gray, of Cape Rosier; J. M. Vogell, of Castine; and John E. Kelly, of North Boothbay. Acknowledgment of the courtesies extended by these gentlemen is hereby tendered.

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* London Fisheries Exhibition, 1883. Catalogue of the Economic Mollusca, by Lieut. Francis Winslow, U. S. Navy, Washington, 1883.

B.—NATURAL HISTORY OF THE GIANT SCALLOP.

1.—THE COMMON AND SCIENTIFIC NAMES.

The large pecten of which this paper treats is known among fishermen and others by several names. In localities in which it is the only representative of the genus it is called simply "scallop." In other sections, where the small scallop (*Pecten irradians*) is also found, the designations "giant scallop" and "great scallop" are given with reference to its size, and "smooth scallop" to distinguish it from the conspicuously crenated shell of the common species; the latter name also suffices to differentiate it from the strongly-ribbed valves of *P. islandicus*, a comparatively large deep-water form occurring in abundance off the same coasts adjacent to which the smooth species is found. The name giant scallop is herein adopted as being expressive and appropriate. Capt. J. W. Collins states that at places on Penobscot Bay the fishermen call the species the "hen clam."

The species, or a very closely related form, was first described by Say as a fossil from the Miocene of Virginia and called *Pecten clintonius*. Under various other names* recent specimens were described by Lamarck, Mighels, Linsley, Stimpson, and others.

It is now held by some writers that the fossil and living forms are identical, and the name advanced by Say in 1824 has consequently been adopted by them. The following remarks on this subject are by Professor Verrill:

A comparison of specimens of this Miocene species, from Surrey, Virginia, with the more strongly ribbed, deep-water form hitherto recorded by me as *Pecten tenuicostatus*, var. *aratus*, shows that they are in all respects essentially identical. In the fossil specimens the ribs are much stronger and more regular than in ordinary specimens of *P. tenuicostatus*, but not more so than in many deep-water specimens taken in 65 to 125 fathoms, off Martha's Vineyard; while among the numerous specimens dredged by us, all gradations [occur] between the strongly ribbed form and those forms common in shallow water, in which the ribs are much more slender, indistinct, or almost obsolete. The forms of the main shell and of the auricles are the same, however, in all these varieties. The fossils, like all the recent specimens, show the peculiar fine, oblique striæ or vermiculations between the ribs, both on the body of the shells and on the auricles. In the fossil specimens the ribs, especially those towards the ends of the shell and on the auricles, are crossed by the raised lines of growth in such a way as to form small, rather close, distinctly arched, raised scales; this character, which is not usually seen in the smoother, shallow-water form is found in many of the deep-water specimens quite as prominently or even more so than in the fossils.

There being no doubt, therefore, of the identity of the fossil and the recent shells, the name *Clintonius* should be adopted for this species, on account of its priority, while the name *tenuicostatus* may well be retained to designate the ordinary smoothish, mostly shallow-water variety, found on the New England coast. This name was originally given by Dr. Mighels to very young specimens of this smoothish variety, under the impression that they were a distinct species, but he afterwards recognized the fact that they were only the young of the common species, at that time generally known as the *Pecten magellanicus* Lam.†

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* The principal synonymy of the scallop is as follows:

Pecten clintonius Say, Jour. Acad. Nat. Sci. Phil., IV, 1824, p. 124, pl. 9, fig. 2.

Pecten tenuicostatus Mighels, Proc. Bost. Soc. Nat. Hist., I, p. 49, 1841 (young). This is the preferred name in most recent works.

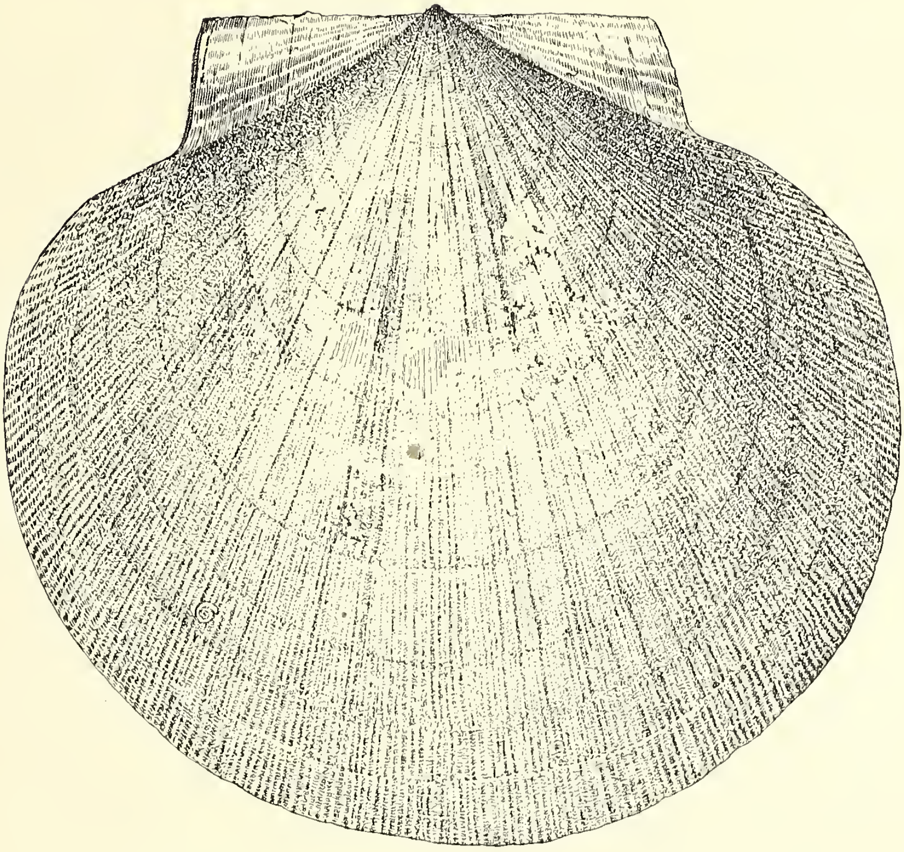
Pecten fuscus Linsley, Amer. Jour. Sci., XLVIII, p. 278, 1845.

Pecten magellanicus Lamarck, Anim. Sans. Vert., ed. II, vol. VII, p. 134.

Pecten brunneus Stimpson, Shells of New England, 1851.

Pecten principoides, Emmonds, Report N. C. Geol. Survey, 1858, p. 280, fig. 198.

† Trans. Conn. Acad., vol. VI. Catalogue of Mollusca of New England Coast, part I, pp. 260-261.



GIANT SCALLOP (*Pecten magellanicus*).

Two-thirds natural size.

Prof. William H. Dall, the honorary curator of the department of mollusks in the U. S. National Museum, in his "Catalogue of the Shell-bearing Marine Mollusks and Brachiopods of the Southeastern Coast of the United States,"* gives preference to the designation of Lamarck, and, under date of October 22, 1890, in reply to an inquiry, writes:

The name *Pecten magellanicus* is by far the oldest, and, in the uncertainty as to the standing of several fossils which have been referred to the species in question, is the one I have adopted.

2.—GEOGRAPHICAL RANGE.

Professor Verrill, in his "Report upon the Invertebrate Animals of Vineyard Sound,"† gives the range of the giant scallop as extending from Labrador to New Jersey. He states that it is rare or local south of Cape Cod. Later explorations have disclosed the fact that the species occurs as far south as Cape Hatteras, and is abundant in many places off the southern coast of New England.

Locally it has been found in the waters of Labrador, Nova Scotia, Bay of Fundy, Passamaquoddy Bay, Frenchman's Bay, Penobscot Bay, Bagaduce River, Sheepscot River, Casco Bay, Massachusetts Bay, George's Bank, Block Island, Connecticut, New York, New Jersey, Virginia, and North Carolina. The mollusk is thought to be most abundant in the Gulf of Maine, off the coasts of Maine and Massachusetts, where several thousand specimens have been brought up from deep water at a single haul of the beam-trawl on the U. S. Fish Commission exploring steamers *Albatross* and *Fish Hawk.*

3.—BATHYMETRICAL RANGE.

The depth at which the scallop has been ascertained to occur varies with the locality, but generally speaking may be said to range from 1 to 150 fathoms for living specimens; dead shells have been dredged at a depth of 400 fathoms. Verrill cites the depth in different sections as follows: Labrador, 2 to 15 fathoms; Frenchman's Bay, 3 to 10 fathoms; Passamaquoddy Bay and Bay of Fundy, 1 to 109 fathoms; Massachusetts and Casco Bays, 4 to 80 fathoms; George's Bank, 45 fathoms. Detailed figures showing the depth of the numerous beds of scallops on the coast of Maine that have been operated by the fishermen are given further on under the head of "Fishing Grounds."

4.—DESCRIPTION OF THE SCALLOP.

Dr. R. E. C. Stearns, of the Smithsonian Institution, is to be credited with the following graphic account of the anatomy of the scallop; although it applies more strictly to the species with crenated valves, the description is no doubt almost equally appropriate to the one under consideration:

The animal of the fan-shells is exceedingly beautiful. The mantle or thin outer edge, which is the part nearest the rim or edge of the valves, conforms to the internal structure of the latter, and presents the appearance of a delicately pointed ruffle or frill. This mantle is a thin and almost transparent membrane, adorned with a delicate fringe of slender, thread-like processes or filaments, and furnished with glands which secrete a coloring matter of the same tint as the shell; the valves increase in size in harmony with the growth of the soft parts by the deposition around and upon the edges of membranous matter from the fringed edge of the mantle which secretes it. This cover is

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* Bull. 37 U. S. Nat. Mus., 1889.

† Report U. S. Commissioner of Fish and Fisheries, 1871-'72, pp. 295-747.

also adorned with a row of conspicuous round black eyes around its base. The lungs or gills are between the two folds of the mantle, composed of fibers pointing outward, of delicate form and free at their outer edges, so as to float loosely in the water. The mouth is placed between the two inmost gills, where they unite. It is a simple orifice, destitute of teeth, but with four membranous lips on each side of the aperture. The mechanism by which respiration and nutrition are secured is elaborate and exceedingly interesting. The filaments of the gill fringe, when examined under a powerful microscope, are seen to be covered with numberless minute, hair-like processes, endowed with the power of rapid motion. These are called *cilia*, and when the animal is alive and *in situ*, with the valves gaping, may be seen in constant vibration in the water, generating by their mutual action a system of currents by which the surface of the gills is laved, diverting toward the mouth animalcules and other small nutritious particles.*

The shell of the scallop has been described as "orbicular, rather higher than long, thin and translucent when young, thick, strong, and opaque when mature, equilateral, inequivalve, the lower valve being nearly flat and not attaining the edge of the upper valve by an eighth of an inch or more; upper valve moderately convex, valves widely gaping near the hinge, surface everywhere sculptured with radiating punctured lines or grooves about half as wide as the spaces between them, somewhat zigzag in their course. These lines are crossed by closely arranged lines of growth, which on the convex valve are scalloped or vaulted over the radiating lines; flattened valve white, convex valve dingy, reddish-brown, or flesh-colored. Hinge margin narrow, straight, ears equal, the notch in the lower valve rounded and shallow. Interior white, smooth, glossy, with minute radiating lines not corresponding to the exterior grooves." †

5.—SIZE, GROWTH AND DEATH, HABITS, ETC.

The scallop shares with other deep-water mollusca the obscurity concerning their life history which is thrown around them by the great difficulties in the way of a comprehensive research. The commercial fisherman, as a rule, is not a close observer of inconspicuous vital phenomena, and he can not be expected to depart beyond a certain point from the realms of practical business to delve in the domain of natural science. In the case of the particular species under consideration, the writer found that what would in almost any other sphere have been an exhaustive inquiry was almost barren of results. Until the establishment of large marine aquaria, in which the lives of fish, crustaceans, mollusks, and other orders can be studied with but little or no departure from the natural conditions, it would appear that a complete knowledge of the habits and of the most practical methods of propagation, cultivation, and protection of many of our important water animals will always be lacking.

Viewed from the standpoint of size alone, the giant scallop is probably the largest edible mollusk on the Atlantic coast of the United States. The average diameter of the specimens taken for market on the coast of Maine is about 5½ inches, although much larger individuals are not uncommon, and those the size of a nickel coin are sometimes brought up. The largest examples recorded from Mount Desert, Castine, and Little Deer Isle have been 9 inches in diameter. The edible muscular portion of a scallop of this size is about 3 inches in diameter and weighs 9 or 10 ounces. The average size of the "meat," however, is a little more than 1 inch in diameter.

The general impression among fishermen is that the scallop is a rapid grower, reaching maturity in a few years. In this respect the giant scallop agrees with the prob-

* Overland Monthly, April, 1873.

† Gould, Invertebrates of Massachusetts, 1870, pp. 196, 197.

able rate of growth in *P. irradians*, which has been more thoroughly studied than any other species in this country. The basis for the belief that the scallop attains the proximate limit of size in a few seasons is that frequently, in the spring, when the fishermen visit a ground on which they have worked the previous fall, the scallops are found to be so small that it hardly pays to take them, while in the succeeding autumn and winter they are as large as in the previous year.

Mr. Heath states that the fishermen of Mount Desert Island find the scallops that are 4 or 5 inches in diameter to be the cleanest, brightest, and liveliest. Those of 8 inches look old, their shells are dingy, rough, and brittle, and are apt to be more or less honeycombed by the chambers of the boring-sponge.

The duration of the life of a scallop after reaching maturity is thought to be quite brief. Some fishermen think that it dies within one year, and it seems probable that the life term is normally not more than 5 or 6 years.

Mr. Benedict, as the result of observations off the Massachusetts coast, thinks that exceptionally at least the scallop attains great age. Mr. Vogell, of Castine, has also seen specimens that were so large, thick, and tough that he estimated their age at not less than 15 years.

Unlike many mollusks, the scallop has the interesting and useful accomplishment of free locomotion in the water. By means of the powerful adductor muscle the animal is able to rapidly close its valves and to forcibly throw out the water between them. The resistance thus arising tends to swiftly propel the mollusk in the opposite direction by a series of short jerks. Few fishermen are aware of this phenomenon and few persons have ever witnessed it, owing to the depth at which the swimming operations usually occur. The sight of a school of scallops moving in unison through the water is said to be a very striking one. The small shallow-water species (*P. irradians*) is frequently seen swimming, or "dancing," as the sliding motion is termed; but only here and there on the Maine coast are fishermen found who have actually observed the habit in the giant scallop.

This faculty of the scallop is probably exercised when in search of new feeding-grounds or of water of a more congenial temperature. It is a matter of personal experience with the fishermen of certain localities to find that the scallop beds shift from time to time, although these wholesale migrations are not nearly so extensive as might be supposed and in some localities are unknown, although not for that reason alone necessarily absent. Inquiry in the vicinity of Mount Desert Island failed to elicit the knowledge of any perceptible change in the position of the beds in that vicinity, which have been operated from the same positions since the establishment of the fishery. Mr. Vogell, speaking of the beds in the vicinity of Castine, says they do sometimes shift, and that there will at times be good fishing on a ground which a week before was destitute of scallops. He assigns the search for food as the cause of the movements. Mr. Gray, of Cape Rosier, has observed that in the summer, after the water becomes warm, the scallops are apt to leave the sites frequented during the cooler months and seek deeper water or retire to grounds with a different character of bottom. The general opinion among fishermen in that section is that upon the return of cold weather, about October 1, they "pod up" on hard, pebbly shoals, with a strong current, for the purpose, it is supposed, of undergoing the reproductive process. Information received in the fall of 1890 stated that no scallops were being found on some grounds that were profitably worked in the spring of the same year, while new

beds were discovered in spots on which no scallops were previously known. In the same locality beds have apparently shifted in a single day; but such striking migrations are thought to be undertaken only by small bodies of scallops.

6.—PARASITES OF THE SCALLOP.

(*a*) *Crabs.*—Like the oyster, the scallop is the host of a species of crab (*Pinnotheres maculatum*) peculiar to it and to the common mussel (*Mytilus edulis*). This parasite is lodged in the gill cavity of the mollusks and appears to exert no injurious effect on their life or growth. Mr. Rathbun writes regarding it:

> It attains a larger size than the oyster-crab, and, as in the case of the latter, the females alone are parasitic, the males having only been found swimming at the surface of the sea. We have never heard of this species being eaten, probably because neither the mussel nor the smooth scallop has ever been much used as a food in this country. In the summer of 1880, while dredging off Newport, Rhode Island, the United States Fish Commission steamer *Fish Hawk* came upon extensive beds of the smooth scallop, from a bushel of which nearly a pint of these crabs were obtained. Again, in 1881, the same species was encountered in great abundance by the same party in Vineyard Sound, in *Mytilus edulis*. As an experiment, they were cooked along with the mussels and found to be very palatable, although their shell is, perhaps, somewhat harder than that of *Pinnotheres ostreum*.*

Mr. F. W. Lunt, of West Tremont, Maine, informs the writer that four or five crabs are sometimes found lodged in a single scallop, and that even as many as ten have occasionally been observed. That the crab is not a constant inhabitant is well known, and some fishermen have never seen it. Mr. L. F. Gott, of Tremont, in preparing several hundred bushels of scallops for market, did not find a single crab.

So far as can be learned, the crabs are never eaten on the Maine coast.

(*b*) *Boring-sponges.*—The shells of many scallops, but more especially those of larger size, are more or less eaten by a boring-sponge (*Cliona sulphurea*), which attacks the shell and honeycombs it in all directions. The upper valve appears to be more frequently affected. Ordinarily the sponge does not pierce the hard, glistening, inner lining of the shell, but confines its ravages to the softer outside layers. When the nacre is perforated, however, the irritation produced causes the scallop to throw over the opening a secretion of lime salts which quickly repairs the injury, and no harm results to the animal. The inner surfaces of some specimens are covered with small papillary elevations that are supposed to have been produced in this way.

The fishermen, as a rule, do not think the sponge is responsible for the borings seen in the shells, but attribute them to a small worm that finds a shelter in the sponge. This worm is by some fishermen thought to be a real enemy of the scallop, and it is said that specimens of the mollusk are often found that have been bored through and killed by it.

The truth of the matter seems to be that the chambers and channels seen in the scallop-shell are made by the boring-sponge, which may sometimes cause the death of the animal by irritation or otherwise. After reaching a certain age the sponge generally dies, and the unoccupied recesses are then appropriated by a worm which is harmless so far as any power to bore through the shell is concerned. Mr. Richard Rathbun, to whom I am indebted for the foregoing suggestion, informs me that there is no worm affecting the shellfish in our waters that is capable of puncturing a shell,

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*The Fisheries and Fishery Industries of the United States. Section 1, text, page 766.

although there are numbers of species that frequent the recesses and holes made by boring-sponges, etc.

(*c*) *Fish.*—A small fish of the genus *Liparis* (the "sea snails," so called) is sometimes found in the scallop, where it goes for protection. It is supposed that in escaping from an enemy it darts between the open valves of a scallop, and these, closing, imprison the fish. It appears to exert no injurious effects on the mollusk, and, no doubt, is glad to escape as soon as the captor opens its valves.

(*d*) *Annelids.*—A number of species of worms are parasitic on the shell of the scallop. The worm tubes of some of them are large and strong, and, with the sponges, often bind the scallops together in a dense mass, as mentioned hereafter.

A small annelid of the genus *Spirorbis* occurs abundantly on specimens of the scallop collected by the writer in Maine; the species is shown on the accompanying figure of the scallop shell.

C.—THE FISHERY.

7.—ORIGIN, DEVELOPMENT, AND PRESENT CONDITION

In the numerous accounts of the scallop fishery contained in "The Fisheries and Fishery Industries of the United States," there is no reference to this industry in Maine, and it may, therefore, be assumed that in 1879 and 1880, the years embraced by that work and prior thereto, the species was unknown as an economic product.* Inquiry has failed to disclose the whereabouts of the giant scallop fishery referred to by Ingersoll (see foot-note), which was discontinued on account of the depletion of the beds brought about by excessive dredging; but it is well known that in certain localities this species of scallop has been used for local consumption for many years.

The existence of large beds of the giant scallop on the coast of Maine, accompanied by an appreciation of their commercial value, became known to fishermen at a number of isolated places about the same time. From numerous inquiries among the fishermen along different portions of the coast, it would appear that in no locality is the fishery more than five or six years old, while in most of the centers it has been carried on less than three years, as will appear from the following history of its origin in the various sections:

Beginning at the east, the towns in the waters adjacent to which the scallop fishery is or has been prosecuted, are Tremont, Mount Desert, Deer Isle, Sedgwick, Brooksville, Castine, Wiscasset, Edgecomb, Newcastle, Westport, Boothbay, and Georgetown.

On the western side of Mount Desert Island, in the town of the same name, the fishery for scallops originated in 1884. It was inaugurated by vessels coming from the

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* In his monograph on the scallop fishery, in volume 2 of section V of the above report, Mr. Ingersoll says (p. 570):

"The splendid large *Pecten islandicus*, which formerly abounded on the coast of Maine and in the Bay of Fundy, is now so nearly extinct that it has become a prize to the conchologist. This came about entirely through excessive raking and dredging for them."

It is suggested that Mr. Ingersoll was probably referring to *P. magellanicus* and not *P. islandicus*, which is a species inhabiting very deep water and never the object of a fishery, or but sparingly used for food, so far as known. This view is borne out by the fact that in a subsequent paper on "The Scallop and its Fishery," published by Mr. Ingersoll in the *American Naturalist* (1886), substantially the same thought is expressed, *P. tenuicostatus* being substituted for *P. islandicus*.

westward and, at first, using an oyster dredge, and later the more effective form of apparatus which has since been generally adopted by the fishermen of this and other localities. The first trials were made in the deep water in the vicinity of Bartlett's Island, Pretty Marsh, and Mount Desert. It would appear that prior to the advent of these vessels the fishermen of Mount Desert were unaware of the existence of scallop beds in their vicinity, or at least of scallops in sufficient numbers to warrant their shipment to distant markets, although, according to Mr. W. W. A. Heath, the efficient and accommodating customs officer at South West Harbor, the line fishermen in the vicinity of Mount Desert Island had for years frequently brought up scallops that had by chance become attached to their hooks. In the winter of 1885–'86 the native fishermen became interested, and as many as twenty men from Bartlett's Island and Pretty Marsh were regularly engaged in taking scallops for the New York market. From that date the fishery declined somewhat, owing, it is said, to the exhaustion of certain of the beds incident to overfishing. In 1887 but four men gave attention to it, and in 1888 and 1889 only seven.

In Tremont the fishery sprung into existence about the same time as in Mount Desert, probably as a result of the same impetus. It is now followed from The Center, West Tremont, or Goose Cove, and Bass Harbor, the fishermen frequenting grounds near Bartlett's Island and other localities south of that place. The number of men engaged in the fishery in the town has decreased during the past few years, there being thirty-one in 1887, twenty-three in 1888, and eighteen in 1889.

The winter of 1886–'87 witnessed the beginning of a scallop fishery at Little Deer Isle which was destined to become the most important fishery of the kind in the State. In 1886 a vessel from Portland visited the grounds off the southern shore of the island, and during that year took considerable quantities of scallops. The native fishermen quickly appreciated the commercial value of their beds, and in 1887 no less than twenty-six persons were regularly engaged in the fishery. More than 5,000 bushels were the result of the first year's operations. Since then the industry has more than doubled in importance, and in 1889 the yield was more than one-fourth that of all other localities combined, although the output of the numerous towns on the Sheepscot River, considered collectively, was considerably larger than that of Little Deer Isle.

The existence of giant scallops in the vicinity of Castine has long been known. Men are still alive who remember to have taken scallops as many as forty or sixty years ago. The town has had a more or less regular local supply for about forty years. Twenty-six years ago, as the writer is informed by Mr. Vogell, a man attempted to make a business of peddling scallops among the people living in places remote from the fishery; but the fine edible qualities of the mollusk were not appreciated by them, and the venture was abandoned. About 1876, the Castine Packing Company undertook to put scallops on the market in a canned condition, as is now so commonly done with clams in many localities on the coast of Maine. It is said that the company was unable to properly preserve the thick, solid meats, and the effort was abortive. Six years ago, however, the attempt was renewed and was in a measure successful. It was found that by previously frying the meats they could be canned without difficulty, but the method was considered too costly and was not put to much practical use; and the fishery, which would otherwise have been maintained by home demand, was diverted to supply distant markets.

The business of taking scallops for shipment to western cities began in the fall of 1884. In the early history of the industry the shipment of 50 gallons of meats in one day was considered very large. Since then the fishery has grown uninterruptedly and reached large proportions, and at times during the past five years as many as 1,000 gallons have been in one day shipped from Castine by the fishermen of that town and Cape Rosier, while the yearly output in favorable years is over 5,000 gallons. Twenty-four men were engaged in this fishery in 1889, a larger number than had previously been employed in the town in any one year.

The fishermen of Cape Rosier frequent waters similar or adjacent to those of Little Deer Isle, and became interested in the fishery about the same time. From thirty-one to thirty-six persons have followed the business each year, the number in 1889 being larger than in any previous season.

Two fishermen from Sedgwick plied their operations in 1888 and 1889 on the same grounds visited by the Little Deer Isle fishermen, but did not engage in the fishery prior thereto.

The history of the scallop fishery in the Sheepscot River dates from 1887. It is stated that the existence of beds was accidentally ascertained by scallops becoming entangled in lobster traps. The discovery was immediately put to practical use. A fisherman of the town of Westport made a dredge adapted to bringing up scallops, and operated it with gratifying results in the river opposite that place. Within a short time other boats were fitted out from the various towns on the river, and the fishery was established on quite a large scale. Two years' steady work on the extensive beds has failed to deplete them, and it seems probable that, with proper forethought on the part of the fishermen, the grounds will not be exhausted for many years, although the conditions for the perpetuation of a profitable fishery are not so favorable as would be afforded by deeper and less circumscribed beds.

The principal fishing is now done by fishermen of Boothbay, Westport, Southport, Edgecomb, and Georgetown. The business has also engaged irregularly and to a very small extent a few fishermen from Newcastle and Wiscasset. In 1889 sixty-four persons followed the fishery, of whom more than a third were from Boothbay. The number of fishermen has increased each year since the inauguration of the fishery; and the quantity of scallops taken in 1889 was larger than the output of any other locality.

There can be no doubt that large undiscovered beds of scallops exist, especially in the deeper waters, on various portions of the Maine coast, that will from time to time be discovered and become available when the present sources of supply are exhausted. The indefatigable "down East" fisherman will not be long in finding new grounds and applying improved methods of capture when the occasion requires, and the perpetuation of this profitable and unique fishery will be secured.

The following ingenious explanation of the presence of scallops on the coast of Maine is from the Bucksport (Maine) Clipper of December 3, 1885:

> The scallop found in such large quantities now along the coast of Maine is not an indigenous bivalve. It was brought here by the early French settlers and planted (in the sea) near their abodes. Its original home may have been the Gulf of St. Lawrence, near the Labrador coast, and Straits of Belle Isle, and perhaps some came from the coast of France. It ought and is to be found the most plentiful near the sites of the old French settlements, such as Castine, Mount Desert, etc., which corroborates the above assertion. * * *

This extract is reproduced simply to correct any impressions it may have made

in the community that the French were responsible for the planting of scallops, which, prior to this feat in artificial propagation, were not, according to this account, found on the Maine coast. That this is a fallacy can readily be shown by citing the existence of this species in a fossil state from Labrador to Virginia, and of large areas covered with the scallop along the whole Atlantic coast as far south as Cape Hatteras, there being no evidence to show that they were originally brought from the Gulf of St. Lawrence, the Straits of Belle Isle, or any other place. It is quite plausible no doubt that the early French colonists on the Maine coast took up scallops from the deeper waters and for convenience planted them nearer their settlements, but it seems altogether out of the question that they should have transported live scallops from Labrador and even from France to Maine, and so formed the vast beds that now exist off the coast of the United States.

8.—APPARATUS AND METHODS OF CAPTURE.

The form of apparatus now in general use in taking scallops resembles in some respects a small oyster dredge, and is called a dredge or scoop by the fishermen. It differs from the oyster dredge in certain features, however, which an inspection of the accompanying figure will readily suggest. The size of the dredge varies somewhat with the locality, but the figure and the following description may be regarded as applying to a dredge of average dimensions.

The essential parts of a scallop dredge are the handle or "pull-bail," the iron frame forming the mouth of the dredge, and the pocket into which the mollusks are received.

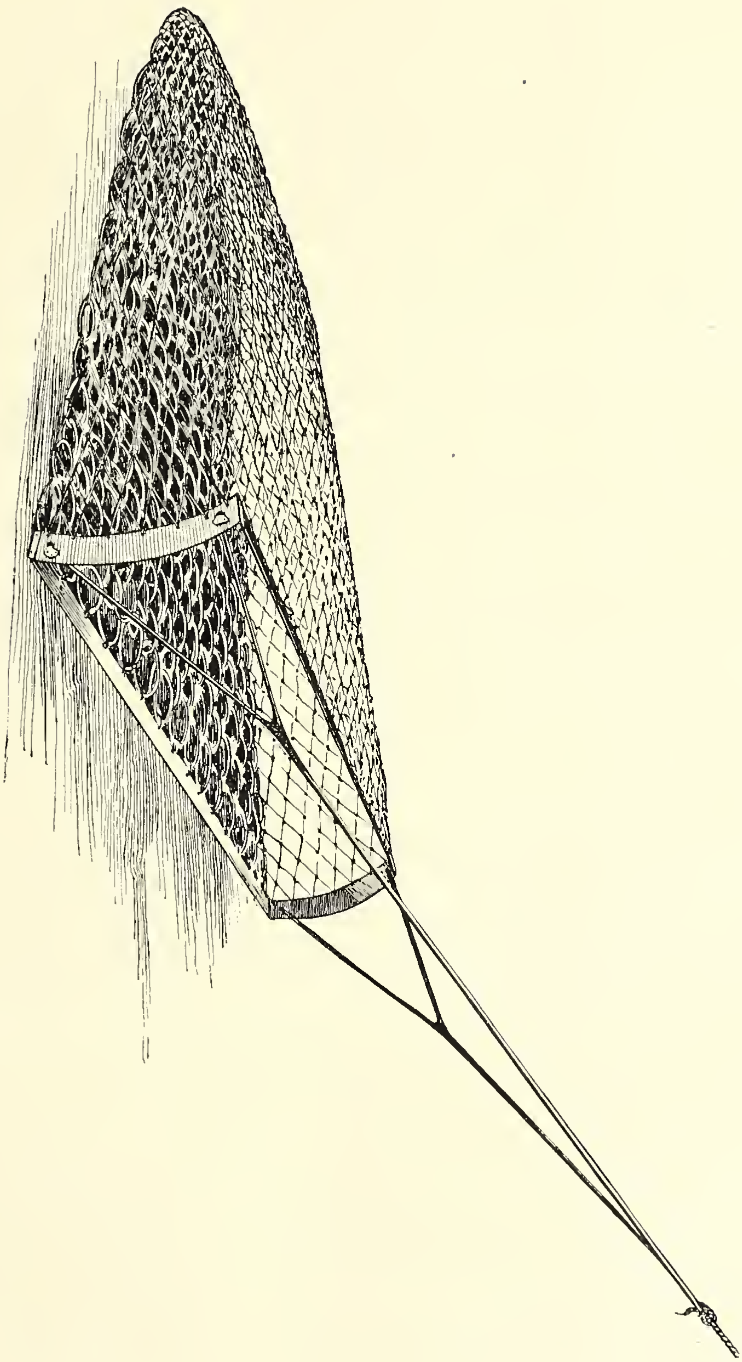
The handle or "pull-bail" consists of two iron bars, which come together at the top and form an eye in which the rope or warp is fastened. The eye is 4 or 5 feet from the mouth of the dredge. Towards the mouth the bars divide and go to the four corners of the rectangular iron frame to which the bagging is attached, and are riveted firmly, so that no motion is permitted. The division of the bars is for strength.

The framework forming the mouth of the dredge is composed of flat iron bars 1½ inches wide and one-fourth of an inch thick. The bars are fastened together as shown in the figure, and form an aperture 3 feet 3 inches by 9 inches. The bagging is fastened to the frame by means of holes made in its inner edge.

The lower side of the pocket consists of iron rings of sufficient size to permit the smaller unmarketable scallops to slip through. Usually the rings are 2½ to 4 inches in diameter. The top and sides of the pocket are made of marline and cod lines. This arrangement of iron and twine is necessary in order to prevent the dredge from rapidly wearing out. The inferior portion is subjected to rough usage in being dragged over the rough bottoms on which the scallops are found, and a bagging other than that described would be unfit for the purpose. That part of the pocket made of netting serves simply to confine the scallops, and is not required to be of metal, which, in addition to being more expensive, would also add greatly to the weight of the dredge and the consequent difficulty of operating it. The pocket is 4 feet in depth and in width corresponds with that of the framework. It has a capacity for about two hundred scallops.

The warp or rope by which the dredge is manipulated varies in length with the depth of water in which it is used. Owing to the oblique position which it occupies

PLATE CXIV.



SCALLOP DREDGE.

when in the water, it is necessarily much longer than would be required to reach simply to the bottom in a perpendicular direction. The usual length of rope is 50 to 150 fathoms.

The value of such a dredge as has been described is about $5, exclusive of the warp. One dredge is the usual complement of a boat carrying two men.

A dredge employed by the fishermen of Castine and vicinity, described by Mr. Vogell, is similar in construction to the specimen figured, but is of considerably smaller size, the framework being 23 inches wide and 9 inches high, the arms of the "pull bail" 20 inches long, and the pocket 24 inches deep.

In fishing for scallops, the warp is tied to a thwart of the boat and the dredge is lowered to the bottom near the edge of the bed. Then both men "lay to" and row over the ground, towing the dredge. If the wind be propitious the sail is raised, and the towing may be exclusively done by the wind, but usually the sail is supplemented by the oars. If the bed be small the men may tow the dredge from one side to the other before drawing it up. When operating on larger beds the dredge is hauled up every 200 or 300 feet, the frequency varying with the abundance of the scallops. When vessels are employed the fishing is carried on from small boats, as elsewhere stated. Sometimes, however, in certain localities, the fishing is done by running out the dredge with a boat and hauling it in from the side of the vessel, which is kept at anchor. The advantage arising from the use of vessels is referred to in the next section.

On the Sheepscot River, where the fishing maneuvers are carried on from large, decked, sloop-rigged boats, provided with a crew of one or two men and fitted out with one dredge, the scallops are taken by sailing back and forth over the beds while towing the scrape. The boats are too large to permit the use of oars, which, moreover, are not required by the nature of the grounds.

9. VESSELS AND BOATS EMPLOYED.

As already stated, the first attempts to take scallops in the vicinity of Mount Desert Island were by men operating in vessels, but the use of the latter never became popular on the island, and they have never been regularly employed. Only a few trials with vessels have been made since the establishment of the fishery. In the vicinity of Castine and Cape Rosier vessels appear to have been in greater favor than elsewhere, and several have been employed annually. The following statement shows the vessels which, from time to time, during the past 3 years have been devoted during a portion of the season to scallop fishing:

Name of vessel.	Net tonnage.	Fishing grounds.	No. of boats carried.
Allena L. Gray	15.02	Penobscot Bay and tributaries	2
Commerce	46.20	Penobscot Bay and tributaries	7
Cygnet	13.17	Off Mount Desert Island	2
Major	6.62	Penobscot Bay and tributaries	2
Ripple	24.29	Off Mount Desert Island	2

The schooner *Allena L. Gray* was built in 1889 and first used in the scallop business from Cape Rosier in the season of 1889–'90. As an example of the amount of

work that can be done with vessels, it may be stated that, during the period indicated, this schooner took 1,400 bushels of scallops.

It should be remembered that even when vessels are used the actual fishing is done from small boats carried for the purpose, the vessel simply serving as a lodging place for the crew and to freight the catch to the shipping point. The usual complement of a vessel engaged in this fishery is one boat to every two men of the crew, the boats ordinarily being dories, pea-pods, and other common types.

It may be of interest in this place to point out what appear to be some of the advantages and disadvantages of vessels and boats in this fishery. When the industry is carried on primarily from boats the men are forced to make short trips, are interrupted in their operations by rough weather, and are obliged to return to shore to shuck and otherwise prepare the catch for shipment. On the other hand, with a vessel anchored on the grounds, the facilities for taking care of the catch are as good as those on shore, there is less time lost in landing the products, time can be economized by "weathering" moderate storms and resuming operations as soon as fishing becomes possible, ice can be carried with which to preserve the catch until a full fare is secured, better opportunity is afforded for getting the scallops to the shipping place, and in various other ways it would appear that the vessel or decked boat is, on the whole, more serviceable and efficacious. The advantage is not so great, however, when the fishing grounds are inshore or adjacent to the point of shipment.

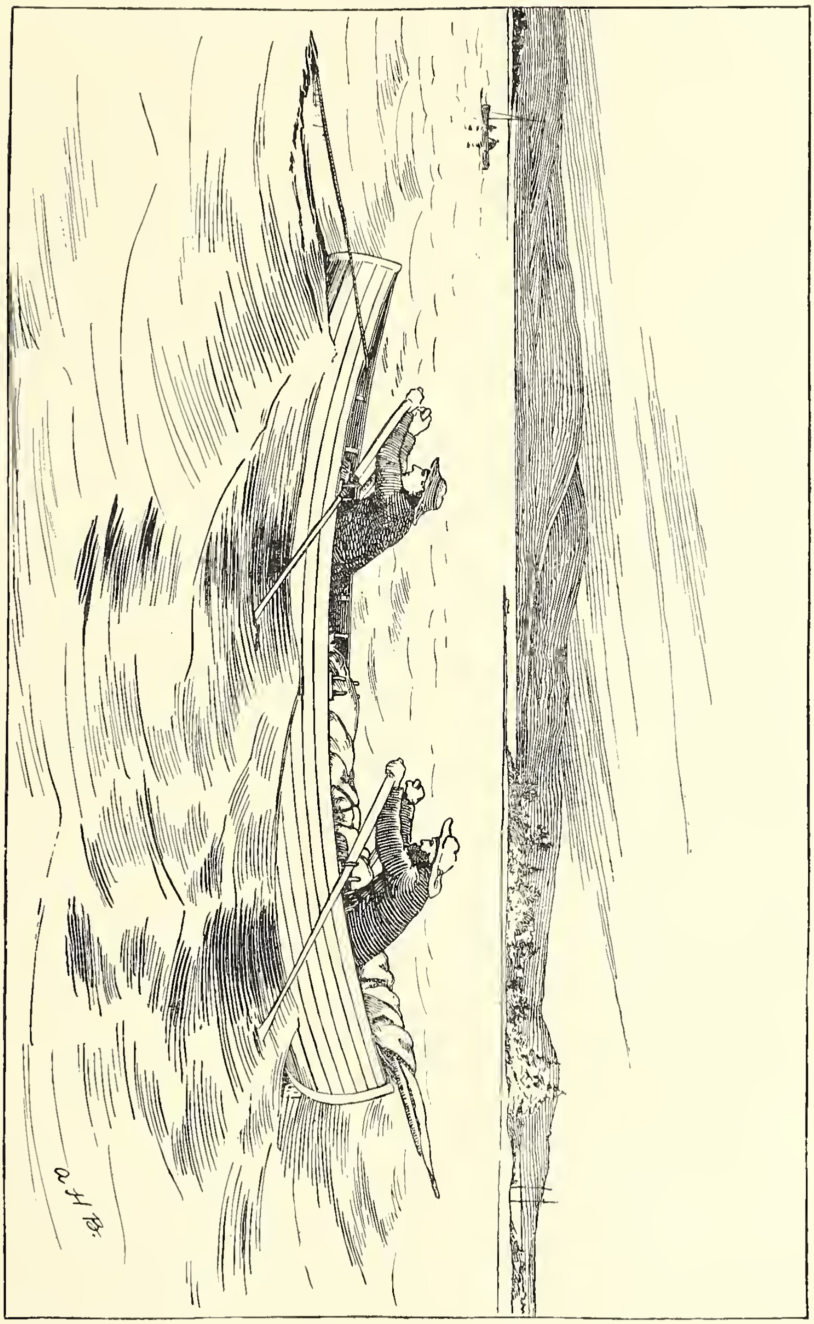
No special types of boats are employed in the shore fishery. There are few scallop fishermen that do not at some period during the year engage in other branches of the fisheries, and the same boat is employed for both purposes. The scallop boats, therefore, are the ordinary forms found in the region, varying with the localities in which the fishery is prosecuted. Consequently we find that in the Mount Desert and Little Deer Isle sections, pea-pods are the prevailing class, while farther west dories are in most common use. In the vicinity of Castine and Cape Rosier the employment of small, decked, sloop-rigged boats has recently been increasing, the number at the latter place having advanced from 1 in 1887 to 6 in 1889. On the Sheepscot River the favorite form of craft is also a sloop-rigged boat. The pea-pods and dories have an average value of $15, and the decked boats range in price from $100 to $200, those in the Sheepscot River being, as a class, the most expensive.

Generally speaking, the larger a boat the less serviceable it is in this fishery, other things being equal. This is especially true where rowing is the method of propulsion and sailing is not followed at all or is only supplemental to it. When sailing is chiefly followed, the objections to a craft of large size are not so potent, up to a certain limit. It is said that there are considerable difficulties in the way of properly operating a boat over 25 feet in length, and the fishermen in most localities prefer a much smaller one. In the eastern portion of the scallop territory, that is, between Castine and Mount Desert Island, the fishermen consider the most useful kind of a boat to be about 16 feet in length.

In 1888, it is reported that a man in the vicinity of Castine employed a small steamer in the scallop fishery, but unsuccessfully, and the attempt was abandoned.

10. THE FISHING GROUNDS.

(*a*) *Location of the beds.*—All the scallop beds, the existence of which was known and on which the fishermen operated in 1889, are shown on the accompanying map.



TOWING A SCALLOP DREDGE OFF MT. DESERT.

PLATE CXVI.

SCALLOP GROUNDS AT MOUTH OF BAGADUCE RIVER, MAINE.

The position of the beds, as given on the chart, is based on information and descriptions furnished by fishermen and other responsible parties in the different sections. In the absence of any surveys or other definite means of locating the grounds, their position, as well as their size and shape, must be understood as being only approximately correct, although, for the purposes of this paper, it is sufficiently accurate.

The position of the beds may be briefly summarized as follows:

Off Mount Desert Island.—Nine beds have been discovered in this vicinity. Three are adjacent to Bartlett's Island, one being near the northern end, at the entrance to the narrows; another off the southeastern end, opposite Pretty Marsh Harbor; and the third off the southern extremity. The fourth bed runs parallel with Hardwood Island, between it and the shore of Mount Desert Island. Two of the remaining beds are near Moose Island, and the others are located some 3 miles off the coast and 4 miles south of Moose Island, in the neighborhood of Ship Island. The four beds first named are the largest, and those last mentioned the smallest, those at Moose Island being intermediate in size as well as in position. It is somewhat interesting to observe that all of these beds, extending over a tract 10 miles in length, run north and south in an almost direct line.

Off Little Deer Isle and Cape Rosier.—A large area lying south of Little Deer Isle and Cape Rosier, between these places and North Haven Island, is more or less covered with scallops, which are taken jointly by the fishermen from Little Deer Isle, Cape Rosier, Sedgwick, and occasionally Castine. The area embraced between the peripheral beds is about 45 square miles, and includes numerous islands, among which the largest are Eagle, Bare, Butter, Spruce Head, Little Spruce Head, Beach, Colt Head, Bradbury, Crow, Pickering, Eaton's, Sheep, Western, Pond, and Hog Islands. Between or clustered around these the beds are found. More beds are known to exist in this region than in any other on the Maine coast, although they are mostly of small size. Of the thirty-four separate beds operated in 1889 only three were of large dimensions. Two of these were east of Hog Island, and the other east of Pickering Island. New beds are continually discovered in this region, as the smaller and older beds are exhausted.

Bagaduce River, Lawrence Bay, and off Brooksville.—Prior to 10 years ago the only bed in the vicinity of Castine, the existence of which was known by the fishermen, was some distance up the Bagaduce River. Since the demand for scallops has increased, the fishermen have had to search for other sources of supply, and Mr. Vogell states that new beds of greater or less extent are now found almost every year. In 1889 there were five beds in the Bagaduce River. Two of these, of considerable size, were above Castine, another large bed was nearly opposite that city, and a smaller one was situated a little nearer the mouth of the river; the fifth, a medium-sized bed, was at the junction of the river with Penobscot Bay.

Smith's Cove or Lawrence Bay is an indentation of considerable size in the Bagaduce River, opposite Castine. Near the head of this body of water a small bed existed in 1889.

Immediately north of Holbrook Island a bed was operated in 1889 similar in size to that occurring in the mouth of the Bagaduce River. A very large area directly west of Holbrook Island and nearest to the shores of Islesborough is known to exist, which is thickly covered with scallops. Its limits are somewhat in dispute, owing to the fact that but few fishermen ever essay to work it because of its depth, which is

for the most part over 45 fathoms. This has proved to be too deep for regular profitable fishing. Southwest of this large bed, and still nearer Islesborough, a much smaller bed has been found, which is chiefly visited by Cape Rosier fishermen.

Sheepscot River.—The scallop beds in the Sheepscot are of greater extent than those found elsewhere in the State. They begin a short distance north of Sweet's Island and extend up the river in a more or less unbroken chain to within about 2 miles of Wiscasset. An offshoot also enters Cross River, a tributary of the Sheepscot, to the distance of about a mile. The area covered by the scallops in this river is about 7 miles long, and, in the widest part, opposite Barter's Island, from one-quarter to one-half a mile across, tapering in the upper course of the river to conform with the width of the stream. It is estimated that not less than 2 square miles of bottom are covered by these mollusks in the river in question.

(*b*) *Depth of the beds.*—The depth of water in which scallops occur no doubt accounts in a great measure for the comparatively few localities in which the mollusks have been found. It is well known that vast beds exist off the Maine coast, but these are inaccessible to the fishermen both on account of their depth and their distance from the shore.

The beds which are worked on the coast of Maine may be said to range from 4 to 40 fathoms in depth. The depth varies with the region and with particular spots in each region. The most important soundings, as gleaned from the fishermen and the charts of the United States Coast Survey, may be briefly stated as follows for the principal beds:

Location of beds.	Approximate range of depth.	
	Fathoms.	
Bartlett's Island, northern end	7½ to	11
Bartlett's Island, eastern side	9	25
Bartlett's Island, southern end	10	35
Hardwood Island	34	40
Moose Island	15	21
Numerous beds between North Haven and Cape Rosier.	4	27
Bagaduce River, upper beds	3	8
Bagaduce River, bed at mouth	5	12½
Holbrook Island	9	13
Large bed off Brooksville	20	46
Sheepscot River	6	22
Average	11	24

(*c*) *Shape and character of the beds.*—Data relative to the shape and thickness of the scallop beds are not so abundant or conclusive as could be desired. In general it may be stated that the areas covered by scallops are usually irregularly oval in outline and the proportional length of long and short diameters appears to depend entirely on the strength and direction of the current, the major axis in all cases being in the line of the current. This is very noticeable in the Bagaduce River and the beds around Bartlett's Island, for instance, where the feature can be directly traced to the action of the water.

The fishermen in some localities think that the scallops are sometimes disposed in a shape approximating a broad-based cone, and when not so placed that they lie one upon the other in several layers, most thickly aggregated towards the center of the bed. The opinion also prevails that some beds at least are raised a foot or more above the level of the surrounding bottom.

However this may be, it is known that the mollusks lie thickly on the bottom, and that ten or twelve successive hauls may often be made over the same spot before the scallops appear to be seriously diminished.

Mr. James E. Benedict, for some years the naturalist on board the U. S. Fish Commission exploring steamer *Albatross*, informs the writer that in many localities off our coast the scallops lie very thickly on the bottom, and are so closely matted together by the sponges and worm-tubes that locomotion is impossible. Under such conditions the working of the beds would probably be promotive of the growth and improvement in the quality of the individual animals and the expansion of the beds, by breaking up the masses of mollusks and giving them an opportunity to exercise their locomotive faculties in search of new feeding grounds.

(*d*) *Nature of the bottom.*—Scallops can not be said to prefer any particular kind of bottom, and their presence in a given locality is rather to be attributed to favorable conditions of salinity and temperature than to the character of the bottom. In certain places the mollusks may be found on a rocky bottom, for instance, to the exclusion of other kinds, while in an adjoining section they may occur only on soft sticky mud.

Off Mount Desert Island the greatest variety of bottom is found. The beds adjacent to the northern and eastern sides of Bartlett's Island and off Hardwood Island are on soft bottom, as ascertained by the U. S. Coast Survey. The bed at the southern end of Bartlett's Island is on rocky bottom. Sticky mud predominates off Moose Island. Mr. Heath remarks that the scallops in that vicinity occur on bottoms of rock, reddish gravel, hard clay, and dead shells.

Mr. Gray has found that the numerous beds in the Penobscot Bay, between Eagle Island and Dice's Head, occur mostly on the hard, rocky bottoms, some of them so rugged that a dredge can not be used thereon. The large bed near the Islesborough shore appears to be chiefly on clay and mud.

In the Bagaduce River the bottom is mostly rocky. Mr. Vogell states that the scallops do not there occur on soft bottom, but seem to prefer hard, smooth areas, covered with free rocks from the size of pebbles to stones so large that a dredge is sometimes caught behind them and lost.

In the Sheepscot River, black and gray sand and mud appear to be the predominant forms of bottom.

11.—FISHING SEASON.

The fishing season varies in the different localities. It depends chiefly on the proximity of the markets. Generally speaking, where there is a good local demand in the vicinity of the scallop beds, the fishery may continue throughout the year; in other cases, with distant markets, the fishery has to be regulated by the weather and is confined to the colder months, during which shipments may be safely made for long distances.

On Mount Desert Island, the months of July and August see the greatest activity among the scallop fishermen, and the bulk of the catch is made during that time; in November and December a few men also follow the business; during the remainder of the year, however, the output is small and uncertain.

At Little Deer Isle, an isolated center, the principal operations are carried on from the first of December till the termination of cold weather in March or April; in

1889–'90 it extended from December 1 to March 20. A small amount of fishing is also done in the fall.

The season at Castine and Cape Rosier usually begins November 1 and terminates April 1. The winter of 1888–'89 was an open one and therefore unfavorable to the business.

In the Sheepscot River the scallops are taken only during the winter months.

12.—RESULTS OF THE FISHERY IN 1887, 1888, AND 1889.

The aggregate output of the fishery in 1887, 1888, and 1889, respectively, was 35,204 bushels, 29,578 bushels, and 45,368 bushels. The equivalent numbers of gallons were 23,277 in 1887, 19,028 in 1888, and 29,851 in 1889. The total value of the products as sold by the fishermen was $13,994 in 1887, $11,278 in 1888, and $18,647 in 1889. The output of the different localities is shown in detail in the accompanying tables.

In the first year the localities yielding the largest quantities were, in their order, Castine, Sheepscot River, Tremont, Little Deer Isle, Cape Rosier, and Mount Desert. In 1888 and 1889 the order varied somewhat. The Sheepscot River is to be credited with the largest catch, followed by Little Deer Isle, Castine, Cape Rosier, Tremont, Mount Desert, and Sedgwick.

The average stock per man in 1889 was only $95 and is always necessarily low, owing to the large number of persons who engage in the fishery only irregularly, and also to the short time during which the fishery is prosecuted in most localities. It should also be borne in mind that few, if any, men depend exclusively on scalloping for a livelihood. The following table shows the fluctuations in the average stock per man in the different localities during the past 3 years:

Table showing the average stock of persons engaged in the scallop fishery.

Locality.	1887.	1888.	1889.
Mount Desert	$150	$125	$100
Tremont	92	63	54
Little Deer Isle	65	51	139
Sedgwick	....	33	50
Cape Rosier	54	44	106
Castine	125	118	119
Sheepscot River	71	60	74
Total	85	64	95

Men who may be said to have made a business of scalloping during the continuance of the season stocked quite as much as usually results from other fisheries for the same length of time. For instance, at least fifteen men in Castine and Cape Rosier annually take scallops to the value of $200 each, although the average stock of the fishermen of those places is only about half that sum.

13.—SUGGESTIONS FOR THE POSSIBLE ADVANCEMENT OF THE FISHERY.

The probability of making large fares, were it possible to operate to advantage on the deeper beds, suggests the need of a more improved form of dredge. With the present dredge it is not easy to take scallops at a greater depth than 30 fathoms. Probably the most extensive beds lie beyond that depth and have never been disturbed

by man. There seems to be no doubt that a rich harvest awaits the man who first uses a form of apparatus that can be operated in almost any reasonable depth of water, say 100 fathoms.

In the oyster fisheries of the Chesapeake the need of such an apparatus has long been felt to compensate for the depletion of the inshore beds by making available new and productive grounds that can not be reached by the ordinary forms of apparatus. Through the ingenuity of Mr. Charles L. Marsh, of Solomon's Island, Maryland, a simple device has been patented which makes it possible to take oysters in any depth of water. The apparatus is essentially similar to the ordinary tongs so commonly used, but is devoid of handles. The latter made it impossible to take oysters in a greater depth than 30 or 35 feet, and even with that depth the work is not devoid of much fatigue and unsatisfactory results. That a similar form of tongs, made on the same principle, can be advantageously employed in deep water in the scallop fishery there can be no doubt. Its advantage over the common dredge is as great as its superiority over the ordinary oyster tongs. Requiring the services of but one person, it can be operated from the side of a vessel by each member of the crew, and it can also be employed in small open boats carrying one or two men. The disadvantage of having to row and sail back and forth over the grounds is done away with; it is possible to locate the bed before unlocking the tongs, thus making sure of the catch; and although more costly it is more economical in the end, because requiring the services of fewer men and insuring greater results in a given time.

The experience of the U. S. Fish Commission has demonstrated that the beam-trawl is the most effective apparatus for the capture of scallops. By means of it many bushels have been brought up at a single haul off the Massachusetts coast. It seems proper, therefore, to speak of it in this connection as a possible substitute for the smaller dredge on many portions of the coast of Maine.

In using the beam-trawl it would be necessary to work on smooth bottom, since rough, stony ground would tear the net. Fortunately the deep-water beds are believed to be generally on bottom that is suitable for operating the beam-trawl; at least many such areas have been found in the explorations of the Fish Commission.

The beam-trawl is somewhat more expensive than the dredge, but its effectiveness is believed to be vastly greater. Besides, a small trawl, with a 12 to 15 foot beam, can be operated with the same number of men that is needed for towing a dredge. A large sailboat could tow the trawl and, with the assistance of some sort of mechanical device to raise it (like a capstan, or the winch that is used by the drift-net fishermen of Great Britain), it could be easily managed by two men.

Small steam vessels or launches could probably be successfully employed in this fishery if the demand for scallops reaches proportions that call for the employment of additional capital and a material increase in the output. Their use would do much to economize time and to increase the catch while, of course, steam could be utilized to hoist the trawl.

For information concerning the beam-trawl, its manipulation, etc., the reader is referred to the exhaustive paper on the subject by Capt. J. W. Collins.*

*The beam-trawl fishery of Great Britain, with notes on beam-trawling in other countries, etc. Bulletin U. S. Fish Commission, Vol. VII, 1887.

D.—THE USES OF THE GIANT SCALLOP.

14.—THE FOOD VALUE OF THE SCALLOP.

Scallops in general have always been highly esteemed for their edible qualities, and in many localities are regarded as among the choicest products of the water. Although such a comparatively new article, the size of the giant scallop, as well as its flavor, has already secured for it a steady and growing demand, and it seems destined to maintain a prominent place in the estimation of the epicurean and the public. Unfortunately, the usual retail prices are so high that the great mass of the people have never been permitted to partake of this luscious food.

As will be seen in the paragraph giving quotations of the wholesale prices of scallops in the Boston market, the Maine species appears to be regarded somewhat less favorably than the smaller mollusk taken in Rhode Island and the vicinity of Cape Cod.

Mr. James E. Benedict found that specimens secured in deep water off Cape Cod by the *Albatross* were not so delicately flavored as *P. irradians*, although he considered them very fine. He explained that these individuals were bound together on the bottom in great crowded masses by the worm-tubes and boring sponges, so that growth, reproduction, and feeding were interfered with and the animals were unable to avail themselves of the function of swimming, the exercise of which would naturally have tended to improve their quality. The beds found in shoaler water are not so seriously affected by these parasites and shift from time to time, as has been shown. The scallops are therefore of better quality.

Prof. W. O. Atwater, in an elaborate paper in the Report of the United States Commissioner of Fish and Fisheries for 1883, on the chemical constituents of marine food products, gives tables showing the relative food value of fish, shell-fish, crustaceans, etc., as indicated by the percentage of protein, fats, carbo-hydrates, and mineral matters which they contain. The protein compounds or albuminoids have a threefold function in the economy, to quote Professor Atwater: (1) They form the basis of blood, muscle, connective tissue, etc.; (2) they are transformed into fats and carbo-hydrates, and are stored as such in the body; (3) they are consumed for fuel. The fats are (1) stored as fat and (2) consumed for fuel, and the carbo-hydrates (starches, sugars, etc.) are (1) transformed into fat and (2) consumed for fuel. Protein, representing the essential portion of food, performing the functions in part of both fats and carbo-hydrates, in addition to forming the basis of blood, muscle, and other tissues, is to be taken as the standard in comparing the food values of different substances.

Reference to the following table, adapted from Atwater, showing the proportion of watery and solid constituents in all the common edible mollusks and the percentage of protein, fats, carbo-hydrates, and ash in the solids or nutrients, discloses the fact that scallops* surpass all of the other shell-fish in the total percentage of nutrients and in the proportion of protein. It is also somewhat interesting to observe that oysters rank last in the list.

* The analysis is that of the small scallop (*P. irradians*), which can not differ materially from the giant scallop, for which no analyses are available.

Table showing, by weight, the proportion of watery and nutrient constituents of certain mollusks.

[Adapted from Atwater.*]

Constituents.	Scallop.†	Oyster.‡	Long clam.‡	Round clam.‡	Mussel (*Mytilus edulis*).‡
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water	80.3	87.3	85.9	86.2	84.2
Nutrients or solids	19.7	12.7	14.1	13.8	15.8
Protein	14.7	6.0	8.5	6.6	8.7
Fats	0.2	1.2	1.0	0.4	1.1
Carbo-hydrates	3.4	3.5	2.0	4.2	4.1
Minerals	1.4	2.0	2.6	2.6	1.9

* See Report U.S. Commissioner of Fish and Fisheries, 1883, p. 443.
† Edible portion, *i. e.*, adductor muscle.
‡ Shell contents.

15.—ON THE USE OF SCALLOPS FOR BAIT.

The bait question on the New England coast has ever been an important one, and of late years it has attracted the attention and demanded the consideration not only of those directly interested in the prosecution of the commercial fisheries, but also of the lawgivers and diplomats of the land. Whatever, therefore, may be done to call attention to possible new sources of supply, to be utilized in periods of scarcity of the regular bait products, seems worthy of presentation.

This preface brings us to a consideration of the use of scallops as possible substitutes for or coequals with the soft clams (*Mya arenaria*) as bait in the hand-line and trawl fisheries. It may be said at the outset that experiments with scallops have not as yet been sufficiently complete or exhaustive to decide what their real value is or just how high a place they are destined to occupy in the estimation of the fishermen. Even if it be finally ascertained that they are inferior to clams, their possible utility should be remembered; and there will no doubt be times in the history of many fishing localities when a supply of fresh or salt scallop bait will not be wholly worthless.

One of the earliest specimens of giant scallops that reached the hands of the conchologist was obtained from the stomach of a codfish.* Since then, scallops have been repeatedly found in the stomachs of cod and other marine species usually known under the general name of "ground fish." From this circumstance the suggestion no doubt arose of the probable value of the mollusk as a bait; it does not appear, however, that anything more than irregular or spasmodic attempts have been made to employ it, owing possibly to prejudice, but chiefly to a misapprehension of its value.

A strong reason for the use of the scallop for bait lies in the fact that the portion of the animal which can be so utilized is now considered valueless. As is well known, only the muscular portion of the meat is marketable for food, and the "skirts" or "rims" are regarded as a waste product by the fishermen and consequently thrown away. This waste is enormous, amounting in 1889 to not less than 30,000 gallons. When it is considered that this figure represents above 1,500 barrels of salt bait, which could have been secured for but little more than the cost of the barrels and salt, the great actual loss to the fishermen may be appreciated, especially in view of the probable value and efficacy of this kind of bait.

* Under the name of *P. fuscus*, Linsley, in 1845, described this species of scallop from a specimen taken from the stomach of a cod caught at Stonington, Conn. See synonymy, in foot-note, page 314, of this paper.

A number of isolated trials with both fresh and salt scallops have come to the notice of the writer. The consensus of opinion seems to be that in a fresh condition they are quite as attractive as clams. When salted, however, there is a difference of sentiment, the burden of the testimony being that in the bank fisheries they are somewhat inferior to clams, although until more conclusive experiments are made the matter must be regarded as *sub judice.* The information received regarding the use of scallops in the shore fisheries is that they have proved fully as good as clams when given an impartial trial.

Mr. J. M. Vogell, of Castine, states that in 1887 a fisherman in that vicinity took 5 barrels of scallop bait on a trip, but he failed to make a satisfactory fare, and no one in that region has employed the mollusk since that time.

At Mount Desert Island, pickled scallops have been sparingly used on a number of occasions during recent years in the line fisheries and are reported to have given as good results as clams.

There seems to be no reason why the scallop fishermen, when shucking these bivalves, should not preserve that portion of the animal which is now discarded, following the same method in curing it that is now pursued in the clam bait-fishery. At a comparatively small outlay for salt and barrels, and with practically no loss of time, what is believed to be a really valuable salt bait could be put on the market and the fishermen would be financially benefited to the extent of perhaps $5,000 or $7,000 annually.

16.—UTILIZATION OF THE SHELLS.

The beauty of the scallop shells has secured for them a demand that is not as yet very extensive, but appears to be yearly increasing. They are in considerable favor with artists, who paint marine and other views on the smooth interior; and they are also employed in the making of pincushions and other similar ornaments. The chief market at the present time is Bar Harbor, where, in addition to the foregoing uses, the Indians and others fashion them into attractive baskets and other receptacles.

The shells have been more or less frequently used at restaurants and fashionable dinner parties where the search for the unique has suggested the substitution of this article for a plate in serving numerous fancy food-preparations. For this purpose they have been brought as far as Washington. Scallops have also been served in their own shells.

A homely use of the shells is mentioned by Captain Collins, who remembers that in the Penobscot region they were formerly sometimes employed in skimming milk, and they may still be used for that purpose.

The sales of shells at the present time do not amount to more than $100 annually; but it would doubtless be desirable for the fishermen in all localities to remember the economic value which these products have, and to endeavor to create a more regular demand that would no doubt contribute noticeably to the financial results of the fishery.

E.—PREPARATION OF PRODUCTS, MARKETS, ETC.

17.—HANDLING THE CATCH, SHIPMENTS, ETC.

The scallops which are considered large enough for market range in diameter from 4 to 8 inches, averaging about 5½ inches. Few individuals less than 4 inches are ever utilized, the fishermen in most places, with commendable forethought, either returning them to the water when brought up in the dredge along with the larger specimens or having the rings forming the bag of such size that the small ones pass through unharmed.

From ninety to one hundred and ten scallops are usually required to fill a bushel measure. The largest specimens, perhaps, are secured around Mount Desert Island, while in the Sheepscot River they are relatively smaller.

In many localities a bushel of scallops, when shucked, will yield a gallon of meats. At Castine, Little Deer Isle, and Cape Rosier, however, about 1½ bushels are usually required to shuck out a gallon of meats, and on the Sheepscot River about 2 bushels are considered as equivalent to a gallon. The weight of a gallon of meats is 9 to 9½ pounds.

Practically the entire production of scallops is placed on the market in a shucked condition, the few sales in the shell being either local or to fill special orders.

After returning from the fishing grounds the fishermen repair to some spot on the shore or to an outhouse, and there, assisted in some localities by the women and children of their families, open the scallops, retaining the thick, firm adductor muscle ("eye" or "heart," so called) and throwing away the mantles or "skirts," except in the few instances noted. The meats are placed in buckets, boxes, firkins, etc., holding from 1 to 20 gallons, and, when destined for more distant markets, are in a frozen condition or in cold storage during transportation. Shipments are commonly made by the fishermen themselves and not through the intervention of a local dealer. The scallops, except in rare instances, are sold on commission.

It seems worthy of remark that the practice of soaking the meats, which is so prevalent at certain places on the Massachusetts coast and elsewhere, is not followed, so far as known, in Maine. By immersing the meats of the small scallop (*P. irradians*) in water from ten to sixteen hours, they are greatly increased in bulk, and the result is that what was originally a gallon becomes 1 gallon and 3 quarts. It is evident that this is a profitable procedure. If for any reason, however, the sale of such meats is much delayed after reaching market and the surplus of water is lost by evaporation, the scallops are much inferior in quality to those that have not been so manipulated. It is said that the inception of soaking of Massachusetts scallops may be attributed to the fact that the meat of the Maine species is so much larger that it was almost closing the Boston market against the small but equally palatable *Pecten irradians.*

18.—MARKETS.

Boston is now the principal market for scallops, receiving almost the entire output of certain centers. Smaller quantities are consigned to New York, Philadelphia, and numerous towns in Maine, among which may be mentioned Portland, Bangor, Augusta, and Belfast. When the shipping of scallops from Mount Desert Island first began,

practically the entire catch was sent to New York, but of late, owing to the close proximity of Boston and the creation of a more steady demand, the bulk of the yield has been shipped to that place during the colder months. During the open season at Bar Harbor and other fashionable resorts on the island, nearly all the scallops taken in that region find a ready local sale. The output of Little Deer Isle is mostly sent to New York and Philadelphia. Boothbay and the other towns and settlements on or adjacent to the Sheepscot River receive a large part of the catch of that stream, the shipments to distant places being limited.

19.—PRICES.

Although the prices received for scallops at the beginning of the fisheries have not been maintained, they have not declined so materially as to prevent the profitable prosecution of the fishery at the present time; and it seems probable that with the growing demand for the mollusk the prices are not destined to reach any lower basis than the average for the past three years.

At the inception of the fishery, the scallop meats often sold for $2.50 or more per gallon. As the supply increased the prices dropped and at times have reached the low figure of 25 cents per gallon. The average value to the fishermen during the years 1887–'89 was between 50 and 75 cents, although not infrequently $1 and $1.25 have been obtained.

The prices naturally vary with the supply and the demand and the state of preservation in which the scallops reach market.

Mr. F. F. Dimick, the secretary of the Boston Fish Bureau, states that there has been little if any variation in the average prices of Maine scallops in the Boston fish market in the past two or three years, during which time the wholesale value ranged from 50 cents to $1.25 per gallon.

Regarding the relative value of the giant scallop and the small species taken in Massachusetts and Rhode Island, Mr. Dimick finds that in Boston the Rhode Island stock is the most highly esteemed, while the scallops from Cape Cod rank next, followed by the Maine species. The ruling prices received by the fishermen for the Rhode Island goods are from 75 cents to $1 per gallon, and by the wholesale merchants from $1 to $1.50. The scallops from Cape Cod bring 50 cents to $1 at first hands and 75 cents to $1.25 at wholesale.

F.—STATISTICS OF THE FISHERY.

20.—*Table of persons employed.*

Locality.	1887.	1888.	1889.
Mount Desert	4	7	7
Tremont	34	23	16
Little Deer Isle	26	42	44
Sedgwick	....	2	2
Cape Rosier	31	31	36
Castine	36	22	28
Sheepscot River	33	48	64
Total	164	175	197

21.—*Table of boats and apparatus.*

Locality.	Boats.						Value of apparatus and accessories.			Total investment.		
	Number.			Value.								
	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.
Mount Desert	2	4	4	$30	$60	$60	$33	$65	$65	$63	$125	$125
Tremont	17	12	9	389	272	170	322	226	159	711	498	329
Little Deer Isle	13	21	22	195	315	330	169	273	286	364	588	616
Sedgwick	......	1	1	......	25	25	......	15	15	......	40	40
Cape Rosier	16	16	24	440	440	1, 345	230	230	373	670	670	1, 718
Castine	31	24	32	1, 085	945	1, 395	330	262	345	1, 415	1, 207	1, 740
Sheepscot River	22	31	41	3, 208	4, 590	6, 075	215	310	412	3, 423	4, 900	6, 487
Total	101	109	133	5, 347	6, 647	9, 400	1, 299	1, 381	1, 655	6, 646	8, 028	11, 055

22.—*Table of products.*

Locality.	1887.			1888.			1889.		
	Number bushels of scallops.	Equivalent number of gallons.	Value to fishermen.	Number bushels of scallops.	Equivalent number of gallons.	Value to fishermen.	Number bushels of scallops.	Equivalent number of gallons.	Value to fishermen.
Mount Desert	800	800	$600	1, 170	1, 170	$875	935	935	$700
Tremont	7, 856	6, 106	3, 126	2, 653	2, 372	1, 440	1, 541	1, 241	864
Little Deer Isle	5, 070	3, 380	1, 690	6, 415	4, 274	2, 137	12, 074	9, 713	6, 104
Sedgwick	......	......	......	98	65	65	150	100	100
Cape Rosier	3, 593	2, 395	1, 760	2, 842	1, 895	1, 360	5, 880	3, 920	2, 810
Castine	9, 623	6, 415	4. 490	5, 950	3, 967	2, 588	7, 488	4, 992	3, 344
Sheepscot River	8, 262	4, 181	2, 328	10, 450	5, 285	2, 813	17, 300	8, 950	4, 725
Total	35, 204	23, 277	13, 994	29, 578	19, 028	11, 278	45, 368	29, 851	18, 647

SYNOPSIS OF ARTICLE.

17.—A CONTRIBUTION TO THE LIFE HISTORY OF DIBOTHRIUM CORDICEPS LEIDY, A PARASITE INFESTING THE TROUT OF YELLOWSTONE LAKE.

BY EDWIN LINTON, PH. D.

[With Plates CXVII-CXIX.]

I.—INTRODUCTION.

In July and August, 1890, I was requested by the Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries, to investigate this interesting parasite. My instructions were to join with Prof. S. A. Forbes, of Champaign, Illinois, in the field work of an expedition sent out by the U. S. Fish Commission for the purpose of investigating the life of the principal lakes and streams of the Yellowstone National Park, Wyoming, the special work assigned to me being to determine, if possible, the cause of the prevalence of parasites among the trout of Yellowstone Lake.

I desire in this connection, to express my deep gratitude to Professor Forbes for the unabated interest which he took in my branch of the work and for the valuable hints and suggestions which I received from him. I should also be remiss if I did not express my personal obligations to Capt. F. A. Boutelle, U. S. Army, Superintendent of the Park, whose enthusiastic interest in the expedition and prompt assistance in many ways contributed very much to the successful conduct of the investigation. Mr. Elwood Hofer, our esteemed guide and friend, and Mr. F. D. Booth did much volunteer work which receives but inadequate compensation in this mention of their names.

II.—BIBLIOGRAPHY.

The literature relating to this parasite is confined for the most part to the reports of the U. S. Geological Survey, under Dr. F. V. Hayden.

The first mention of the worm that I find is in the Report on Montana and Adjacent Territory for 1871, p. 97, where Dr. Hayden remarks as follows respecting the trout of Yellowstone Lake:

> We were able to discover but one species of fish in the lake, and that was trout, weighing from 2 to 4 pounds each. Most of them are infested with a peculiar intestinal worm, which has been described by Dr. Leidy in a subsequent portion of this report as a new species, under the name *Dibothrium cordiceps*.

I make the following extract from a report prepared at Dr. Hayden's request by Mr. Campbell Carrington and published in the report cited above, pp. 97–98.

A curious fact * * * is connected with these fish, namely, that among their intestines, and even interlaced in their solid flesh, are found intestinal worms varying in size, length, and thickness, the largest measuring about 6 inches in length. On cutting one of these Trout open, the first thing that attracts your attention are small oleaginous looking spots clinging to the intestines, which, on being pressed between the fingers, break and change into one of these worms, small, it is true, but nevertheless perfect in its formation. From five or six up to forty or fifty will be found in a trout, varying, as I said before, in size, the larger ones being found in the solid flesh, through which they work their way, and which in a very short while becomes almost putrid. Their number can generally be estimated from the appearance of the fish itself; if many, the trout is extremely poor in flesh, the color changes from the healthy gray to a dull pale, it swims lazily near the top of the water, losing all its shyness and fear of man; it becomes almost savage in its appetite, biting voraciously at anything thrown into the water, and its flesh becomes soft and yielding. If, on the other hand, there are few or none, the flesh of the fish is plump and solid, and he is quick and sprightly in all his motions. I noticed that it was almost invariably the case when a trout had several scars on the outside of the body that it was free from these worms, and therefore took it for granted that the worms finally worked their way through the body, and the flesh on healing up leaves the scars on the outside; the trout in a short time becomes plump and healthy again.

Mr. Carrington, after proposing a theory to account for these worms, further states that "while all the fish above the upper falls are more or less affected by them, below and even between the upper and lower falls such a thing as a wormy trout is never heard of."

Allusion to the wormy trout of Yellowstone Lake is made by F. H. Bradly in Hayden's Report on Montana, Idaho, Wyoming, and Utah, 1872, p. 234.

Capt. William A. Jones, in his Report on Northwestern Wyoming, including Yellowstone National Park, 1873, p. 22, speaks of this parasite as follows:

We find, as others before us, that the trout of the lake (Yellowstone) are perfectly splendid in size and condition, but are full of parasitic intestinal worms, which leave the intestines and enter the flesh.

The specimens submitted to Dr. Leidy for examination were in a bad state of preservation. It was therefore difficult to make out details of structure. Upon comparing my specimens with Dr. Leidy's figures I was at first led to think that there might be two distinct species of the genus *Dibothrium* represented by the parasites of these trout, but I now think that the difference must be due to the macerated condition of the material upon which Dr. Leidy based the original description.

I make the following extracts from Dr. Leidy's notice of this worm, which was published in Hayden's Report on Montana and Adjacent Territory, 1871, pp. 381–382:

Among the specimens submitted to me were several of the worms inclosed in oval sacs imbedded in fragments of flesh. The sacs having remained unopened preserved the contained parasite from the general decomposition of the others, so as to enable me to ascertain its character. It belongs to the genus *Bothriocephalus*, or rather to that section of it now named *Dibothrium*. Two species have long been known as parasites of the salmon and other members of the same genus of fishes in Europe, but the tape-worm of the Yellowstone trout appears to be a different one.

Two of the best-preserved specimens of the tape-worm measure 5 inches in length by a line in width at the broadest part. The head, almost a fourth of a line in diameter, is obcordate, as represented in the magnified figures subjoined. The two bothria or suckers are thick and discoidal, placed back to back, obcordate in outline, and directed with their broad and slightly depressed surface toward the margin or narrower diameter of the body. The body is flat, thick, with rounded margins, and is narrowly annulated. The annulations appear to be due to muscular bands, and number about ten to the line. If other segments exist, independent of these annulations, as a character of the worm, the

condition of the specimens does not allow of their distinction from transverse fractures at irregular distances. No genital apertures could be detected at the sides or at the margins. Internal organs of any kind could not be seen, but the soft interior tissue of the body is filled with round corpuscles resembling in appearance starch-granules. These proved to be composed of carbonate of lime, as they were completely dissolved by acetic acid with the evolution of carbonic acid. From the shape of the head this tape-worm might appropriately be named *Dibothrium cordiceps.*

My attention was first called to this parasite in December, 1889, when specimens were sent me for identification by the U. S. Commissioner of Fish and Fisheries. These had been collected the previous autumn by Dr. Jordan, who published some account of them in his report on the fishes of the Yellowstone National Park.* These specimens, although in a good state of preservation, were in poor condition to show superficial characters owing to their crumpled and contorted condition. The bothria on the larger specimens were indistinguishable. The larva have the power of retracting the head, which character indeed seems to be retained to a certain degree in the larger specimens, and specimens on this account often do not exhibit the specific characters plainly. The report in which I published an account of this parasite, and which contains notes on the anatomy of this and another *Dibothrium* from the sucker (*Catostomus ardens*), gives, therefore, a rather meager description of the superficial anatomy of this worm. In my first report on this worm I suggested that some of the fish-eating birds inhabiting the lake would probably be discovered to be the final host of this parasite of the trout. When, therefore, the opportunity was afforded me of investigating the matter, I made an examination of such piscivorous birds as I could secure, with the result given below.

III.– LARVAL STAGE.

In the larval stage, *Dibothrium cordiceps* occurs either in cysts among or on the viscera of its host, the trout (*Salmo mykiss*); free, on or among the viscera; beneath the peritoneal lining of the abdominal cavity; or burrowing in the muscular tissue of the body-wall.

The cysts, which are in reality blastocysts or nurses, within which the larvæ develop, are of various sizes. Some were found less than 1 millimeter in diameter, others were 12 millimeters or more in the longer diameter. The smaller cysts are globular or sub-oval, the larger ones are oval. The smaller larvæ up to a centimeter or more in length are lanceolate, flattish, tapering rather abruptly and uniformly to each end. The larger specimens are linear, increasing slightly in breadth posteriorly, with a blunt truncate or emarginate termination; the body is crossed by fine transverse wrinkles, closely crowded together, but in the longer specimens presenting the phenomenon of distinct segments one-half millimeter or more in length. In the living specimens the vascular system is quite evident. It consists of four longitudinal vessels, two near each margin, the smaller vessel of each pair being near the margin. Branches from each of the marginal vessels extend to the other and from each of the larger vessels to the other. These branches also anastomose with each other by means of secondary branches (Fig. 11). The aquiferous vessels unite with two oval vessels at the posterior end, which is often emarginate, with a terminal pore at the emargination (Fig. 13).

The head in the living worm is small and extremely variable, sometimes stretching out until it is linear and not more than one-fourth the ordinary diameter (Fig. 6);

* Bull U. S. F. C., 1889, pp. 41-63.

sometimes abruptly linear from the body, which then appears to be shouldered anteriorly (Fig. 4); at other times the whole anterior part of the body becomes exceedingly attenuate; sometimes it is swollen or truncate at the apex (Fig. 5); sometimes rounded linear or spatulate; sometimes triangular, wedge-shape, and even retracted until it is no longer distinguishable. The bothria, or suctorial pits, are lateral, and the head is flattened so that its broadest aspect is seen when the worm is lying on its edge or shorter diameter (Fig. 9). The edges of the bothria are rather thin and lip-like and are often crumpled or thrown into sinuous folds owing to longitudinal contraction of the head (Figs. 1, 2, 3, 7).

The color is usually ivory white or translucent white with an occasional tinge of yellow.

There is no indication of genital organs other than that mentioned in my previous paper of clusters of nuclei, shown in thin sections, lying along the median line near one of the lateral faces, thus indicating that in the adult the genitalia are median and the apertures lateral.

DISTRIBUTION.

This parasite occurs, so far as known, only in the Rocky Mountain trout (*Salmo mykiss*). I have found it in the trout of Yellowstone Lake, Yellowstone River above the lower falls, and in Heart Lake. I did not succeed in getting any fish from below the lower falls, for examination. I am told, however, that wormy trout are never found in the river below the lower falls. It is very probable, however, if careful search were made for them, that an occasional trout in the river and its tributaries below the lower falls would be found with cysts of this parasite. At the Grand Cañon Hotel I examined some trout which were said to have been caught below the upper falls and found one with cysts in the abdominal cavity and a large larva among the abdominal muscles. In Heart Lake I found the trout not infrequently infested with this parasite, occurring in cysts and free on and among the viscera, but not among the muscles.

Dr. Jordan reports that the trout of Riddle Lake, which drains through Solution Creek into Yellowstone Lake, are apparently free from parasites. It may be that this conclusion would have to be abandoned if an examination were made of several of the large trout of that lake.

Following is an abstract of notes made at the time of collecting, inserted here for the purpose of showing the actual occurrence of this parasite in the fish examined:

HEART LAKE.

All of these trout were taken in front of our camp near the Rustic Geyser Basin, with trammel-net and hook and line.

(1) *July* 26.—Found one trout near shore with wounds on its sides, from the effects of which it was dying; had evidently been struck by a fish hawk; no dibothria.

(2) Ten trout examined; a few cysts found on serous coat of intestine and pyloric cœca; only two of the number had many cysts, about a dozen each. The serous coat of the intestine of these two was somewhat congested and the swim-bladder was more deeply colored than in the others.

(3) *July* 28.—Eight trout examined, most of them with a few cysts, as in No. 2. In one there was a larval Dibothrium in the abdominal cavity on the outside of the

serous membrane. It was translucent white, bluish with transmitted light, 20 millimeters in length and 1.75 millimeters in breadth.

(4) Four trout examined; a few cysts in each, and a free larva 31 millimeters in length, yellowish white; one cyst, 9 millimeters by 4.5 millimeters in the two principal diameters; when opened, liberated an active larva 15 millimeters in length and 1 millimeter in breadth. Along with larva in the cyst was a considerable amount of milky-white nutrient material. Larvæ were seen to make their escape from cysts that had been left lying for an hour or two in water.

Mem.—The Dibothrium cysts are found in the majority of the trout, but usually not in great numbers. Often the development appears to have been arrested, and the cyst degenerates into a calcareous or waxy calculus.

(5) *July* 29.—Six trout examined; only one found with cysts in abdominal cavity.

(6) *July* 30.—One trout examined; a few cysts among pyloric cœca.

YELLOWSTONE LAKE.

(7) *August* 1.—Five trout examined; taken in trammel-net near camp on west arm of lake near Lake-shore Geyser Basin; all with cysts, two with many, one with worms in flesh, three with worms escaped from cysts, and one with worm under peritoneum, not yet in flesh. Of these five trout the first was a male about 35 centimeters in length, few cysts; the second a female, same size, about thirty small cysts, the largest 3 by 6 millimeters, on pyloric cœca, some of the cysts with the larvæ escaping, some yellowish and waxy, two cysts on ovary, the largest 12.5 millimeters in length, cyst about size of a small pea in the liver; the third, a male, same size, several cysts on pyloric cœca, one larva about 5 centimeters in length nearly free from its cyst; the fourth, a male, same size, two or three cysts on pyloric cœca, one cyst under peritoneum, not in flesh; the fifth, a male, a little larger than the others, about thirty-six cysts on the pyloric cœca, one larva 38 millimeters long outside of pericardial cavity, two cysts in testes, one larva in flesh a short distance back of right ventral fin 5 centimeters in length, coiled irregularly, flesh surrounding it inflamed and sore, pit made from peritoneal side, two others under peritoneum of air-bladder, surrounded by inflamed tissue, with apparently a good deal of lymph exuded. One of the larvæ taken from the muscles of the latter specimen, after lying in water for two hours, measured 24 centimeters in length, and an hour or two later 34 centimeters in length; greatest breadth 2.5 millimeters.

(8) *August* 2.—One trout caught with hook and line near warm water of geyser basin, a spent female; two hundred and twenty cysts of various sizes on pyloric cæca; one larva in flesh, beneath peritoneum, on left side back of pectoral fin; one on left side back of gill slit; two on right side back of gill slit; one in liver; a few cysts scattered along intestine and ovary; fish in poor condition. Five trout examined, caught with hook and line a short distance from entrance of warm water; few cysts, no flesh worms. Five others from near warm water, caught in trammel net, more or less infested with cysts; one large larva in intestinal wall of one of the fish, intestine adherent to body wall and larva beginning to penetrate the latter; one larva in flesh above the lateral line, near the dorsal fin; four others from same lot; several cysts, none in flesh. Nine others, caught with hook some distance from warm water; no worms in flesh; a few cysts on intestines and in ovaries of a female.

(9) *August* 3.—Twenty-two trout examined; seventeen of these with from few to many cysts; six of the latter with larvæ escaping from cysts or under peritoneum; one larva measured 54 centimeters in length after lying for eighteen hours in water; five without any parasites.

(10) *August* 4.—Three trout examined; two males with few cysts, one female with several cysts, and one larva burrowing under the ribs.

(11) *August* 6.—Four trout caught with hook, north end of lake, not far from outlet; one or two cysts in each of three males; one female had a few cysts on pyloric cæca; no flesh worms.

(12) *August* 7.—Thirty-one trout caught with hook, north end of lake; five with worms in the flesh, twenty with cysts only, for the most part with only two or three; six without parasites.

(13) *August* 9.—Nine trout caught with hook in southeast arm of lake, not far from inlet; one with several cysts in abdominal cavity and larvæ under peritoneum. Six taken from near mouth of cold stream from mountain side; four of the latter with cysts on pyloric cæca, and one with a larva about 30 centimeters long in flesh near back-bone; five others, no flesh worms, two with cysts.

(14) *August* 13.—Examined a number of small trout from 12 to 20 centimeters in length, caught in the head waters of Alum Creek, South Fork, above hot springs. No cysts or other evidence of parasites discovered after very careful search.

(15) *August* 25.—Examined twenty trout caught in Yellowstone River near outlet of lake; only one was found to be much infested with parasites. It was a female and in poor condition. The parasites were on and among the pyloric cæca; no flesh worms noticed. On same date examined another lot of about a dozen trout superficially. Only one of them was in bad condition. Upon opening it a large number of larval dibothria were found in the abdominal cavity. The soldiers who were fishing there said that they found the fish of the river less commonly parasitized than those of the lake.

(16) *August* 26.—At Grand Cañon Hotel examined three small trout caught just below the upper falls. There was no indication of dibothria in these fish. A large trout, 36 centimeters in length, also said to have been caught below the upper falls, was in poor condition, and had several cysts and migrating dibothria on the pyloric cæca. There was, in addition, a large larva under the peritoneum and burrowing through the kidneys into the muscular tissue. Another specimen, said to have been taken above the upper falls, was also in poor condition. There were many cysts in the abdominal cavity, but no larvæ in the flesh. Another from the lake was in good condition, but had several cysts on the pyloric cæca.

In the above extracts from my notes the only parasite of which account is taken is *Dibothrium cordiceps*. As a matter of fact the trout are infested by a number of parasites. A small *Distomum* is common in the lower intestine, and a slender, white nematod in the intestine in the vicinity of the pyloric cæca. Nematods are not uncommonly found encysted among the viscera, and some very peculiar soft globular cysts, filled with a granular fluid, looking like tumors, covered with a layer of peritoneum, which is richly supplied with capillaries, when opened liberate a small nematod. The latter have not yet been studied. A lernean parasite is also common, usually on the fins or at the base of the fins, and not rarely in the mouth.

When the size of the trout is not mentioned it may be understood to be about 35 centimeters long.

Spent females seemed to be more commonly parasitized to a serious degree than others, although my examinations have not been extensive enough for safe generalizations in this particular.

From this investigation one might conclude that the trout of Yellowstone Lake are not so badly infested with the flesh parasites as they have been in previous years. This may be due to the fact that the observations were made earlier in the season than those of Dr. Jordan for example, who found the worms more abundant than they appear to be now. It is to be noted, however, that larvæ in various stages of development are obtained from the same individual. In one case cysts no larger than a grain of wheat were associated with others larger than a pea, and others from which the larvæ had escaped and begun to burrow into the flesh of their host, attaining a length of 16 centimeters or more and a breadth of 3 or 4 millimeters.

It may properly be inferred from this that the source of infection continues through several months of the year, thus showing marked contrast with the large ligula of the Witch Creek sucker, *Catostomus ardens*, in which case the nearly uniform size of the parasite points to a source of infection supplied, perhaps, by the short sojourn of some migrating piscivorous birds.

With regard to the escaping of these parasites through the skin of the host, mentioned by Mr. Carrington, I was unable to find any confirmatory proof. In a few instances I found that the parasites had penetrated the muscular tissues and were lying immediately beneath the skin; more commonly they were on the peritoneal side of the body wall or burrowing in the muscles. I saw no evidence in the fish which I examined that parasites had escaped. If it can be demonstrated that these parasites really do leave the intermediate host and take to the uncongenial medium of the water, it would furnish an instance of self-destruction unusual among cestod parasites.

I was frequently asked, while in the Park, if these worms are in any way injurious to man. I think it can be safely answered that they are not, except as their presence might make the fish less acceptable to the palate. Fish, perhaps more than any other animals, are required by nature to harbor parasites. There is probably not a food fish in the world that does not furnish a home for one or more species of parasites in some stage of the latter's existence. Fortunately fish parasites, as a rule, do not live in man; at any rate, the various processes of preparation for food to which fish flesh is subjected effectually destroy the vitality of the parasites. It may be, if not pleasant reading to the fastidious, at least consoling to the timorous, to know that forms closely related to the subject of this sketch are in some places actually eaten as food and esteemed as delicacies by those who eat them, who, it may be inferred, ask no questions either for conscience' sake or for the sake of knowledge. Ligulæ, parasites of the European tench and of other related fish, are used as food in Italy, where they are sold in the markets under the name *maccaroni piatti*, and eaten usually under the mistaken notion that it is the roe of the fish. It is also eaten in Lyons by many, where it goes by the appropriate and truthful name of the *ver blanc*.*

* Donnadieu, Contribution à l'histoire de la Ligule. Extrait Journal de Anatomie et de la Physiologie, P. 1.

IV.—ADULT STAGE.

I have found a large Dibothrium in the white pelican (*Pelecanus erythrorhynchus*), which is evidently the adult form of *D. cordiceps*, of which the trout (*Salmo mykiss*) is the intermediate host.

Of the four birds examined, two contained this parasite. These were situated about the middle of the intestine. They were in several fragments in each case, but there was no tendency shown to separate into individual proglottides. Some of the fragments were slender and attenuated, and when studied subsequently proved to be the older parts of the strobiles degenerated into slender ribbons of connective tissue and still containing eggs. In one of the birds, the length of the fragments, which evidently belonged to a single strobile, was about two meters. There was in addition to this an approximately equal amount of attenuated fragments of degenerated portions of the strobile.

The fine impression made by the stately movements of the pelican while on the water or in the air is not sustained on closer acquaintance. It has an abominably rank and fishy smell. It is grievously tormented with parasites. The alimentary canal of an adult bird is from 2 to $2\frac{1}{2}$ meters in length, and throughout its whole extent it is liable to be infested with various parasites. Least numerous and least painful are the dibothria in the intestine.

The mouths of each of the four birds examined contained hundreds of some mallophagous parasite. These were attached to the mucous membrane by the head, and required a sharp pull with the forceps in order to detach them. They were attached in clusters, so that a dozen or more could be removed at one time with small forceps. They were on the inside of the pouch, near the larynx, in the larynx itself, in the beginning of the œsophagus, and in the buccal cavity generally. The œsophagus contained an immense number of a rather slender nematod, 10 to 15 millimeters in length; these were usually attached to the mucous membrane, and left a small round hole when removed. In the lower part of the œsophagus and in the stomach there were also large numbers of nematods. These were larger than those in the œsophagus, with thickish, usually dark-colored, bodies; they were not attached to the mucous membrane, but in the stomach were in the midst of the food.

The stomachs of each of the birds contained practically nothing but partly digested fish.

Much of the stomach contents of each of these birds had suffered so little from the processes of digestion that the size of the fish could be easily estimated. In each case the fish which had constituted the last meal of these birds were from 30 to 36 centimeters in length, or, in other words, the average size of the trout of the lake. There was a little gravel or coarse sand at the bottom of the stomach and occasionally a little vegetable débris, the feather of a small bird, etc. These apparently had been swallowed incidentally to the main business of eating. These birds were found breeding on Molly Islands, in the southeast arm of Yellowstone Lake, July 10, 1890.

SUPERFICIAL CHARACTERS.

The following description of the superficial characters is based on an alcoholic fragment with scolex attached, and measuring about 75 centimeters.

Head, in lateral view of body, elongated, wedge-shaped (resembling exactly some heads of *D. cordiceps* from cysts in *Salmo mykiss*, which I have collected), largest at base, tapering slightly towards apex, narrower than neck, except immediately at base, where it is of same breadth as neck (Fig. 17). In marginal view of body the head is broader than the neck and subsagittate (Fig. 18). Bothria lateral, lips rather thin and flexible.

	Millimeters.
Length of head	2.00
Diameter, corresponding to marginal diameter of body	.80
Diameter, corresponding to lateral diameter of body	.55
Diameter of neck, lateral	.80
Diameter of neck, marginal	.60

Neck, immediately behind head, crossed by fine lines which, less than 2 millimeters back of the head, divide the body into short but evident segments. The body increases in breadth slowly and uniformly, and at a distance of 30 millimeters from the head is 2.5 millimeters broad; at 60 millimeters, 4.5 millimeters broad, at which point the segments are about 0.5 millimeter in length. At about 40 millimeters from the head a faint, darkish, median line is discernible, which becomes darker and more evident farther back. With a lens this median line is seen, in maturing segments, to be occupied by the reproductive apertures. The dark color is due to clusters of ova. The reproductive apertures are lateral, near the median line of the strobile, not far from the anterior edge of each segment, and on but one of the lateral faces of the strobile. From some of the apertures a short, blunt cirrus was seen protruding.

For about 15 centimeters the strobile was thickish with entire margins, then for about 10 centimeters it was characterized by remarkably ruffled margins. This was in the widest part of the strobile. The segments were here much crowded. The strobile in this ruffled portion is also thickish, at least when it is compared with the succeeding portions. At this point the breadth is 7.5 millimeters, the broadest part of the strobile; the length of the segments, 0.34 millimeter; the thickness about 1 millimeter (Fig. 21).

Beyond the ruffled portion, the strobile becomes flatter, much thinner, and decreases in breadth, while the segments become squarish. A characteristic scalloped margin is produced (Fig. 23) by the frequently concave margins of segments and their prominent posterior edges. Near the posterior end of this fragment the segments had the following dimensions: Length, 2 millimeters; breadth, 4.5 millimeters; thickness, 0.5 millimeter or less. The ruffling of the margin of the median portion of the strobile may be due in part to the action of the alcohol.

Another fragment, smaller in most of its dimensions than the above, presents some characters which should be noted. The entire length is 22 centimeters. The head is somewhat contracted longitudinally and is bluntly rounded in front.

	Millimeters.
Length of head	1.00
Diameter of head, corresponding to marginal diameter of neck	0.75
Diameter of head, corresponding to lateral diameter of neck	0.75
Marginal diameter of neck	0.50
Lateral diameter of neck	0.75

Neck almost immediately crossed by fine transverse striæ, which give rise to distinct segments 5 or 6 millimeters back of the head, where they are one eighth of a

millimeter in length and 1 millimeter in breadth. The terminal segments in this fragment are 2.75 millimeters broad and 1.25 millimeters in length.

This fragment, for the most part, resembles the larger specimen, being flattish, white, roughened by transverse wrinkles, and having its margins at one part of its course ruffled. In one place, however, 7 centimeters from the head, and for a distance of 3 centimeters, it is shrunken, attenuated, and yellowish. A segment in this part measured 1.5 millimeters in length and barely 1 millimeter in breadth. Immediately beyond this the normal segments were 5.75 millimeters in length and 2.5 millimeters in breadth.

Some slender, attenuate fragments, previously alluded to, looking when first collected like tangles of narrow braid, were at first supposed to be a distinct parasite. Subsequent examination demonstrated them to be fragments of mature portions of the large Dibothrium. Following is a more detailed account of these fragments than has yet been given: One fragment, measuring 34 centimeters in length, was very thin, and about 1.5 millimeters broad. In some places segments could be made out. These were much attenuated. Some of them were measured and found to be 3 millimeters in length. In some shorter fragments, which were quite irregular, being flat in places and in others cylindrical, segments were noticed which were 4 millimeters in length and 1.25 millimeters broad. Another fragment, 33 centimeters in length, was reduced throughout the greater part of its length to a mere filament one-fourth of a millimeter or less in diameter. Another fragment, about 30 centimeters in length, was reduced to less than one-half of a millimeter in diameter throughout most of its extent, but widened in each direction, so that each extremity was a little over 1 millimeter in breadth.

A thin fragment was placed in glycerine, and was then seen to contain ova along its entire extent. The ova lay along the median line in clusters, which were somewhat continuous. In this the jointing was indistinct. In some of these fragments the joints are distinct, although there is no tendency in the joints to separate. A fragment, 35 centimeters in length, showed distinct joints in part of its course; in other places the joints were indistinct. This fragment was flat and thin and about 1.5 millimeters wide where it was flattened; in other places it was not quite so wide, owing to a tendency to roll up at the margins. Both the flattened portions and the attenuated, cord-like portions of these fragments were found to contain ova, which were seen to be abundant in specimens made transparent in glycerine. These slender fragments are evidently portions of the larger strobiles, in which the muscular tissue has degenerated, and the whole structure is reduced to a narrow band of connective tissue containing ova.

ANATOMY.

In order to make a comparison of the structure of the adult with that of the larva, portions were stained with borax carmine and cut into thin sections. These were made in three directions, transverse, longitudinal parallel to the margin, and longitudinal parallel to the lateral face.

Sections of the head show that while that organ is somewhat smaller than it is in the larger larvæ, the muscular fibers are much more abundant and more strongly developed (Fig. 34). In outline and arrangement of parts they are the same. There appear to be three principal systems of muscles or contractile fibers in the head,

longitudinal, circular, and radial. Some of the radial fibers, however, are continuous with longitudinal fibers of the body. The first of these, the longitudinal, is fairly well developed in the larval stage, the latter two, the circular and radial, but feebly developed. Each is represented by many strong fibers in the adult. In both larva and adult there is a layer of well-developed longitudinal fibers immediately beneath the cuticle of the bothria. (Fig 34, *s c.*)

The layers of the body have the following disposition (Fig. 27):

(1) The cuticle, which appears, when highly magnified, to contain minute circular fibers.

(2) A thick granulo-fibrous layer, the outer portion of which consists mainly of longitudinal fibers, which, in transverse sections, are seen to be continuous, with radial sheets of connective tissue. The inner portion of this layer is less distinctly fibrous and more granular. In transverse sections the connective tissue of this layer appears as radial fibers, which become thicker near the cuticle, where they are more or less parallel, somewhat branched, the branches anastomosing. Toward the inner part of the layer they lose their parallelism and form a mesh of fine fibers. This layer contains the peripheral system of vessels, which, however, is not so prominent as it is in the larval stage. Towards the inner edge of this layer in mature and maturing segments the granular parenchyma is collected into roundish masses, forming the vitellaria.

(3) A layer of coarse longitudinal muscle fibers. In the interstices between these fibers there are fine connective fibers which extend from the outer granulo-fibrous layer, and are continuous with connective fibers of the central core.

(4) A thin layer of fine circular fibers surrounding a central space.

(5) The central core of the body. This space, where not occupied by the genitalia and the vessels of the water-vascular system, is filled by a net-work of connective fibers in mature segments, but in the anterior immature part of the strobile it contains much granular protoplasm, from which later the genitalia develop, the testicular lobules developing towards the margins, while the cirrus bulb, vas deferens, vagina, ovary, shell-gland, and uterus develop in the vicinity of the median line.

The marginal canals and the aquiferous vessels, which lie in the central core, have practically the same characters, proportions, and disposition as they have in the larval form, as elucidated in my former paper.

A few nuclear clusters, which appear in some of the transverse sections made near the anterior end of the head, are probably nerve ganglia (Fig. 34, *n*). Calcareous bodies, so abundant in the larva, appear to be entirely wanting in the adult.

GENITALIA.

The genital apertures are close together, but distinct, lateral, about on the median line; the male orifice much larger than the female and situated near the anterior edge of the segment; the female orifice is situated behind the male orifice and a little to one side. Sections show that the male orifice (Fig. 25) communicates directly with the relatively large, oval, cirrus bulb, which contains muscular fibers in a loose, open tissue, among which the cirrus is usually retracted. The bulb is embedded deeply in the segment, lying for the most part in the central core between the longitudinal muscle layers. At its base it is in connection with a sub-globular organ (Fig. 25, *p*), which appears to be a short vas deferens, or, since its walls are rather thick and dense

and composed of fine fibers, presumably contractile tissue, it may also function as an ejaculatory duct. The vas deferens joins this from the posterior side. The cirrus is apparently invaginated by means of numerous retractor fibers, which are inserted on the inner wall of the bulb and to the cirrus (Fig. 25, *a*). The testes are oval granular bodies lying in the central core rather towards the margins (Fig. 32, *t*). They communicate with the median vas deferens by means of minute ducts.

The vagina opens near the cirrus, posteriorly to and a little to one side of it. It pursues a somewhat tortuous course posteriorly, apparently reaching the ovary on its dorsal side; near its beginning it expands into a seminal receptacle (Fig. 26.) The ovary (Figs. 27, 33) appears to be a single mass of nucleated cells lying near the posterior edge of the segment and towards the ventral side, near the ventral layer of longitudinal muscles. Its longest diameter is transverse to the longitudinal axis of the segment. The shell gland, as I have made it out, lies near the ovary, somewhat posteriorly on its dorsal side (Fig. 33, *s g*). The uterus is a very voluminous organ beginning on the dorso-posterior side of the ovary and lying in broad folds rather toward the dorsal side of the segment, the folds extending some distance on either side of the median line and occupying nearly the entire length of the segment (Figs. 27, 28, 33). Its caliber is much larger than the diameter of a single ovum. In the older segments the walls of the uterus apparently give way, since the ova in them are seen to be in masses in the central part of the strobile. (Fig. 24.)

There is no indication that the segments separate in any other way than in long chains when mature.

Sections made parallel with the lateral faces of the strobile show a small pore lying a short distance back of the genital apertures and on the same side, *i. e.*, the ventral side of the strobile. This is apparently the external orifice of the uterus from which ova may be discharged.

The ova are rather large, about 0.07 millimeter in length and 0.035 millimeter in breadth. The walls are thin and usually collapsed in alcoholic specimens on one side, so that, in mounted specimens, the ova appear to be bowl-shape. They are of an amber color, do not stain readily, and their contents are granular. They lie in somewhat transversely parallel clusters along the median line, the masses of ova occupying a space approximately equal to one-third the breadth of the strobile.

By counting the ova in a series of sections carried through a mass of ova in a maturing segment, it was estimated that the segment contained 2,300 ova. The fragments from the intestines of one of these pelicans contained approximately over 2,000 segments. This would make 4,600,000 eggs from this strobile. This estimate does not include the ova in the attenuated fragments, which would probably yield as many more. These numbers are only approximations, but they probably are far below the actual numbers. It would be much within the bounds of probability to say that for each pelican on Yellowstone Lake in any season there are 5,000,000 eggs of *Dibothrium cordiceps* discharged into the waters of the lake, under such conditions that make it probable that a small percentage of them eventually obtain lodgment in their proper intermediate host, the trout.

V.—REMARKS ON CESTODS.

During my sojourn at the hotel on Yellowstone Lake, at which time I met several tourists and others from various parts of the country, from England, and from France,

all of whom were more or less interested in the so-called "wormy trout" of the lake, and were especially anxious to know something of the cause of the malady, I found that with an occasional exception it was necessary for me to preface any remarks I had to make in answer to queries by giving a short disquisition on tapeworms in general before I could make it clear that I was not a raving theorist when I stated that the cause of the wormy trout was probably the wormy pelican.

Since this report is likely to fall into the hands of some who may be interested enough to read it, but whose previous reading on the subject of tapeworms has never extended beyond the obtrusive headlines of some quack advertisement, I have deemed it expedient to give a very brief account of the life history of a typical and familiar cestod worm, following this with an equally brief statement of what has been found out with respect to the life history of a near relative of *Dibothrium cordiceps*, before giving an account of what is the probable round of life of the latter worm.

The cestods, then, are a peculiar natural order of worms, all the members of which are parasitic during all or at least the greater part of their existence. As a rule, two animals of different kinds, and related to each other as eater and eaten, are required to enable the cestod to complete its life history. One of these is called the final and the other the intermediate host, the cestod being in each case a more or less unwelcome guest.

Probably the best-known member of this order is the common pork tapeworm (*Tænia solium*), whose intermediate host is usually the pig, in whose flesh it passes the larval or encysted stage of its life, constituting the so-called "bladder worm" or "measles" of measly pork. In order to attain the adult stage it is absolutely necessary that the bladder worm be swallowed by the proper animal. In this case the proper animal is man, in whose intestine the bladder worm becomes the adult tapeworm. The pig is therefore an intermediate and man a final host of the common tapeworm. The life history of the tapeworm proceeds, therefore, in this wise: Man, partaking of improperly cooked pork containing larval tapeworms, swallows one of the latter, which, being liberated by the action of the digestive fluids from the cyst of connective tissue in which it is inclosed, soon finds a lodgment on the walls of the duodenum or other part of the small intestines, where it clings by means of an exceedingly small head provided with minute hooks and four small sucking disks. The body gives rise to a chain of joints or segments, which rapidly mature, and are voided with their contained eggs in the natural way, and, under certain conditions not necessary to detail, find their way into the stomach of the pig. A minute embryo is there developed from each egg, which penetrates the walls of the stomach or intestine, burrows through the tissues, and finally comes to rest, usually in the muscular tissue, where it becomes encysted and develops into the bladder worm. Thus the humble round of its passive, though somewhat eventful, life is complete.

The worm which infests the trout belongs to the genus *Dibothrium*, or as it is frequently written, *Bothriocephalus*. It has been known for some years that certain forms related to this genus, which as larvæ, known by the name *Ligulæ*, infest many of the European fresh-water fishes, more especially the *Cyprinidæ*, reach their final or mature stage in a variety of aquatic birds. This has been demonstrated by the experiments of Duchamp and Donnadieu, who succeeded in raising mature *Dibothria* in the intestines of ducks, which had been fed *Ligulæ* from the Tench. The migrations in this case, as made out by Donnadieu, are as follows: The eggs develop in the water,

where they give rise to ciliated embryos, which bear a close resemblance to ciliate infusoria. These pass into fishes, particularly the *Cyprinoids*, where they become established in the peritoneal cavity. The round of life is completed in the intestines of aquatic birds, where the eggs are rapidly formed.

VI.—REASONS FOR REGARDING THE PELICAN AS THE FINAL HOST OF D. CORDICEPS.

While there seems to be no reason to doubt that the tapeworm found in the pelican is the adult of the trout parasite, it may be well to sum up the evidence which has led to that conclusion.

In the first place, it is to be noted that the parasite of the trout is a true larva and shows no signs of assuming the adult condition in the trout. Even the largest specimens, which have left their blastocysts and migrated into the tissues of their host, show but the faintest beginnings of the reproductive organs. Moreover, no cestod is known to attain the adult condition elsewhere than in the alimentary canal of its proper host. Again, out of the large number of trout examined there was not a single case of a mature worm of this genus in the alimentary canal. A few of the large trout of Yellowstone Lake were convicted of cannibalism, since their stomachs contained remains of trout, the only species of fish in the lake. There is no doubt that a large number of trout of the lake are eaten by larger fish of the same species. If the flesh worm of the trout ever matures in the intestine of the trout, or, in other words, if the trout is both intermediate and final host of this parasite, I should have found some evidence of it. Failing to find the adult in the trout, search had to be made among the animals which feed on the trout. A very brief consideration of the fauna of the Yellowstone region was sufficient to make it clear that the adult form of this worm must live in the intestine of some of the fish-eating birds that inhabit the lake. Moreover, since the cause of infection must extend through several months of the year, as shown by the variety of sizes of parasites occurring in a single fish, the final host is seen to be more probably a bird that stays through the summer than one which is only a visitor. Pelicans abound on the lake, one or more of them being usually in sight, on any part of the lake, at any time of day during the summer months. They have numerous roosting-places and at least one breeding-place on the lake. They are known to be notorious fish-eaters. It is clear, therefore, that collateral evidence alone points strongly to the pelican as a, if not the, final host of the flesh worm of the trout.

Evidence of a more direct nature, however, was obtained by the capture and examination of four pelicans. Their stomachs contained partly digested remains of large trout, and practically nothing else, thus demonstrating their ability to capture the large trout of the lake, and showing that they live exclusively on a fish diet; in the intestines of two of them were tapeworms, which there is no reason to doubt are the adult stage of the trout parasite. When one of these worms from the pelican is compared with a parasite from the flesh of the trout, the head with its characteristic bothria, or pits, is found to be practically unchanged. The strobile, or jointed body of the worm, is, as might be expected, much longer and larger in every way. There do not appear, however, any characters in one that are contradicted in the other.

On August 9, on the shore of the southeast arm of Yellowstone Lake, I picked up at the edge of the water three fragments of a Dibothrium strobile. The largest of these fragments was 70 millimeters in length and 6 millimeters in breadth. It was

mature, contained ova, and was evidently identical with those found in the intestine of the pelican.

This fact confirms what seemed probable from a study of the worms from the pelican, viz: that the strobiles are passed in chains from the birds. The excessively parasitized condition of some of the trout may thus be accounted for.

Again, some of the contents of the rectum of a pelican, in whose intestine specimens of *D. cordiceps* had been found, was preserved in alcohol for examination. Upon examination of a small portion of this material several ova were found which were easily recognized to be ova of *D. cordiceps*. A small fragment of the strobile of the same parasite was also found, which was much frayed evidently by the digestive processes of the host.

It may therefore be taken as demonstrated that both ova and fragments of the strobile of *D. cordiceps* find their way into the water where they may be swallowed by the intermediate host, the trout.

Of course this argument does not quite amount to a demonstration. If some one who has the time, opportunity, and inclination would conduct a series of experiments of feeding specimens of trout parasites to ducks, in which they might develop, or, better, to pelicans, in which I think they will certainly develop, it would serve to raise a part of the history of this worm entirely out of the regions of conjecture.

There remains also to be ascertained the fate of the eggs of the pelican tapeworm after they have been consigned to the water.

VII.—CONSIDERATIONS RELATING TO THE PARASITISM AMONG THE TROUT OF YELLOWSTONE LAKE.

In these considerations two problems will be discussed: First, to account for the abundance of parasitized trout in Yellowstone Lake; and, second, to account for the migration of the parasite into the muscular tissue of its host.

In order to reach a proper understanding of the matter, a brief review of some of the physical features of Yellowstone Lake and the surrounding region is necessary. Yellowstone Lake is a large body of water of very irregular outline, containing about 150 square miles of surface and having a coast line of approximately 100 miles. It lies near the great continental divide and empties through the Yellowstone River into the Missouri-Mississippi River system. About 18 miles below the lake there are two falls in the river. The upper fall is 109 feet in height, the lower, which is one-half mile farther down stream, is 308 feet in height. On the western side of the continental divide there are three lakes, much smaller than the Yellowstone, but still quite considerable bodies of water. These are called Heart, Lewis, and Shoshone, respectively, and each is not more than 8 miles in an air line from the nearest point on Yellowstone Lake. Lewis and Shoshone Lakes empty through Lewis River into Snake River, a tributary of the Columbia. Between them and Snake River there are falls of some 60 feet in height. Heart Lake empties into Snake River through Heart River, but there are no falls on this latter stream.

The natural distribution of fish in these lakes presents some peculiarities which should be mentioned here. In Lewis and Shoshone Lakes there are no fish. This is not due to an absence of food nor to the presence of conditions unfavorable to life, since these lakes were found to be swarming with amphipods, entomostracans, and

insect larvæ. Plainly, therefore, the presence of falls on Lewis River, insurmountable by fish, must be regarded as the real reason why there are no fish in these lakes.

In Heart Lake, on the other hand, there are three or four species of fish, viz, the trout (*Salmo mykiss*), the chub (*Leuciscus atrarius*), the sucker (*Catostomus ardens*), and probably the blob (*Cottus bairdi*), all common species in the Rocky Mountain waters. This fish fauna is therefore what we might expect to find in the lake.

In Yellowstone Lake there is but one species of fish, viz, the trout (*Salmo mykiss*), identical with the trout of the waters on the western side of the continental divide. The lake was found teeming with this species of fish and no other by the first explorers of the region. It is not at all probable that the lake was stocked by the aborigines, and the explanation given by Dr. Jordan is doubtless the correct one, namely, that the trout gained access to the waters of the Upper Yellowstone through Two-Ocean Pass, where the waters of the Yellowstone and the Snake arise from the same swampy meadow on the great continental divide. Prof. F. V. Hayden has shown (Bull. U. S. Geological Survey, vol. v, No. 2, "The so-called Two-Ocean Pass") that during times of high water caused by the melting snows, there is actual connection between Atlantic Creek, a tributary of the Yellowstone, and Pacific Creek, a tributary of the Snake. It seems reasonable, therefore, that the trout, an active and somewhat gamy fish and fond of the colder streams, should make its way over the divide, while it would be exceedingly unlikely that the more logy sucker and chub should, under the circumstances, attain a like distribution.

Since there are no fish in Lewis and Shoshone Lakes it is obviously necessary to make a comparison here only between Heart and Yellowstone Lakes.

The invertebrate life of these lakes, while affording one or two interesting contrasts, presents no differences that would have any bearing on the presence or absence, abundance or scarcity of parasites. There is but little difference in elevation, Heart Lake being 7,469 and Yellowstone 7,741 feet above ocean level. The depth, so far as known, is much the same, although the Yellowstone, being much the larger body of water, will probably be found to have the greater depth. A depth of 146 feet was obtained at a distance of about 800 feet from the west shore of Heart Lake, where the bottom temperature was 40° F. A depth of 159 feet was obtained on the west arm of Yellowstone Lake at a distance of 2,000 feet from the shore, the temperature at bottom being 42° F. A depth of 195 feet was found at a distance of about a mile from shore at the north end of the lake. The temperature of the surface water varied with the time of day, but was practically the same in the two lakes. Near shore, at our camp on the west arm of the Yellowstone, on August 2, at 9 a. m., the surface temperature was 54° F. So far as the temperature of the lake water is concerned and the invertebrate life of the two lakes, the fish in Heart Lake and those in Yellowstone Lake are living under substantially similar conditions. Whatever influence the presence of warm water from hot springs and geysers exerts, the conditions are practically the same, since each has geyser and hot spring regions on its borders and each receives warm tributaries from such regions.

I think it likely that after all the only difference between the two lakes, that touches this question, lies in the fact that, while in Heart Lake the trout are associated with the chub and the sucker, and consequently suffer or profit as the case may be by the mutual reaction which this association implies, in the Yellowstone they are alone and neither profit by the presence of another species, which they might use for

food, nor suffer from having a part of their food supply appropriated by another species, nor receive partial immunity from sudden death by having their co-species furnish a part of the food of their common enemies.

Indeed I am not sure that the proportion of parasitized trout in Yellowstone Lake is so overwhelmingly greater than it is in Heart Lake. While I did not find any flesh parasites among the Heart Lake trout, I found that a great many of them had the parasites in the peritoneal cavity, both encysted and free among the pyloric cœca.

Pelicans were seen frequently during our stay on Heart Lake and their breeding place at the south end of Yellowstone Lake is only 10 or 12 miles away. It would be very strange, therefore, if the trout of Heart Lake were found to be free from these parasites.

Neither am I at all certain that the parasites of the Heart Lake trout never penetrate the flesh of their hosts. However, after examining a great many trout from this lake without finding any penetrating the flesh, it may be worth while to consider this question: Why should the parasites of the Yellowstone trout have the habit of burrowing into the flesh of their hosts, while those of Heart Lake seldom or never do?

I am not sure that I can give an altogether satisfactory answer to this question. It appears to me, however, that the reason for this difference is to be found in the peculiarly isolated and circumscribed situation of the trout in Yellowstone Lake. In Heart Lake the trout have at least two species of fish besides their own to feed upon; in Yellowstone Lake the trout, if they are to eat fish at all, are obliged to resort to cannibalism. This is certainly done to some extent. In a few cases I have found evidence of it in the stomachs of the Yellowstone trout. In each such case the cannibal was a trout above the average size. Mr. Elwood Hofer had also observed this fact and stated as the result of his observation that "occasionally a cannibal is met with, and when it is, it is sure to be a big fish."

The Yellowstone Lake trout are confined to the lake and the river above the upper falls. It is true that this species is found in the river between the falls and below the lower falls, being quite abundant in the Yellowstone River and its tributaries. It is not likely that large fish could be carried over the lower falls and live; small fish and ova, however, might be so transported uninjured. Whatever may be the truth with regard to the passage of fish over the falls, it is certain that no fish could return to the lake after having once made the descent. The trout of the lake, therefore, are compelled to pass their whole life within the limits of the lake and its tributaries, or if they do leave, the door is shut behind them with no hope of its ever opening for their return. In Heart Lake the case is different; not only can the trout leave the lake at will, either by tributary streams or by the outlet, but having left they can return again.

To what extent these fish migrate with the changing seasons and diminishing food supply, I have no exact knowledge. Whatever may be their habits in this regard, the trout of Yellowstone Lake are forced to limit their migrations to the lake and its tributaries, and to the less than 20 miles of river between the outlet and the upper falls. The trout, being thus circumscribed in their range, if from any reason their food supply should fail, must suffer the consequences. They can not seek new feeding-grounds. If their food should be of such a kind as to produce peculiarities of flavor, or if it should contain the germs of disease or parasitism, they will be continu-

ally exposed to the source of contagion or parasitism with no respite, with no seasons of relief except what may be incident to the nature of the germs. It follows, therefore, from the peculiar conditions surrounding the trout of Yellowstone Lake, that if there is a cause of parasitism present in successive years the trout are more liable to become infested than they would be in waters where they had a more varied range. Trout would become infested earlier and in greater relative numbers, and the life of the parasites themselves, that is, their residence as encysted worms, must be of longer duration than would be the rule where the natural conditions are less exceptional.

Again, in such cases of parasitism as that under consideration, where the parasite is a larval cestod and the intermediate host the only animal of its kind in this region, the final host is more likely to partake of parasitized food than he would be if part of his food consisted of other species of fish not harboring this parasite. For example, it may be supposed that pelicans, when in the vicinity of Heart Lake, feed indifferently on trout, chubs, and suckers. Even if the trout stood an equal chance with the others of being eaten, which is hardly to be supposed since it is a more active fish than they, it would then constitute but one-third of the food of the pelican. The chances of the pelican's becoming parasitized would therefore be diminished to one-third what they would be from its diet on Yellowstone Lake. But with this diminished parasitism in the final host would go a smaller amount of eggs from the adult parasites to be disseminated where the fish are likely to get them.

As a matter of fact there can not be this difference between the parasitism of the trout of Yellowstone and of Heart Lake, as these bodies of water are so near together that the pelicans found on the one are the same individuals which visit the other.

While in camp on Heart Lake, and also on the west arm of the Yellowstone, we saw several pelicans, but secured no specimens. After we reached the hotel on Yellowstone Lake I made an excursion to the southeast arm of the lake for the purpose of securing specimens of these birds. The southern end of the lake is as yet almost never visited, and we discovered that the pelicans not only roost, as was known, but also breed on the small islands there. Four pelicans were obtained on Molly Island in a deep bay on the west side of the southeast arm of the lake. Our party were in two rowboats, Mr. F. D. Booth, with our only shot-gun, in company with Messrs. Thompson and Coughlin, visited the island and shot the birds for me. As we had found the pelicans thus far rather shy, I and my companion, Mr. Curl, did not approach the island, but rowed across to the northern shore, keeping well outside of the island for fear of frightening any birds which might be there. I thus, much to my subsequent regret, missed seeing the breeding-place of these interesting birds. Mr. Booth reported that they could easily have secured a boat load of the birds if it had been deemed necessary. He estimated that there were at least five hundred pelicans, young and old, on the island, less than one hundred of which were young. The young were large enough to take care of themselves by running and swimming, but could not fly much. The old birds refused to leave the neighborhood of their young and so could readily be shot. The specimens secured were all adults and measured 92, 96, 97, and 98 inches, respectively, from tip to tip of the wings. They had an exceedingly rank, fishy smell, and the gentlemen who visited the breeding-place bore testimony in a variety of select epithets that the smell of the place was horribly bad. The result of an examination of these birds has already been given. Many gulls were also found breeding on this island.

It is probable that other small islands in the southern end of the lake, for example, Peale's Island in the south arm, may also be breeding-places of the pelican. We saw them on our return, roosting on the south end of Frank's Island, but we did not pass near enough to ascertain whether it was a breeding-place or not.

It is easy to see from the foregoing why the fish of Yellowstone Lake should be greatly infested by these parasites. There are probably not less than one thousand pelicans on the lake the greater part of the time throughout the summer, of which, at any time, not less than 50 per cent. are infested with the adult form of the parasite, and since they spend the greater part of their time on or over the water disseminate millions of tape-worm eggs each in the waters of the lake. It is known that eggs of other Dibothria hatch out in the water, where they swim about for some time, looking much like ciliate infusoria. Donnadieu found in his experiments on the adult Dibothria of ducks, that the eggs hatched out readily in warm water and very slowly in cold. If warm water, at least water that is warmer than the prevailing temperature in the lake, is needed for the proper development of these ova, the conditions are supplied in such places as the shore system of geysers and hot springs on the west arm of the lake, where for a distance of nearly 3 miles the shore is skirted by a hot spring and geyser formation with numerous streams of hot water emptying into the lake, and large springs of hot water opening in the floor of the lake near shore. Trout abound in the vicinity of these warm streams, presumably on account of the abundance of food there. They do not love the warm water, but carefully avoid it. Several persons with whom I talked on the subject while in the park assert that diseased fish, that is to say, those which are thin and affected with flesh-worms, are more commonly found near the warm water, that they take the bait readily, but are logy. I frequently saw pelicans swimming near shore in the vicinity of the warm springs on the west arm of the lake. It would appear that the badly infested or diseased fish, being less active and gamy than the healthy fish, would be more easily taken by their natural enemies, who would learn to look for them in places where they most abound. But any circumstances which cause the pelican and the trout to occupy the same neighborhood will multiply the chances of the parasites developing in both the intermediate and final host. The causes that make for the abundance of the trout parasite conspire to increase the number of adults. The two hosts react on each other and the parasite profits by the reaction. About the only enemies the trout had, before tourists, ambitious to catch big strings of trout and photograph them with a kodak, began to frequent this region, were the fish-eating birds, and chief among these in numbers and voracity was the pelican. It is no wonder, therefore, that the trout should become seriously parasitized.

It may be inferred, from the foregoing statements, that the reason why the parasite of the trout of Yellowstone Lake migrates into the muscular tissues of its host must be found in the fact that the life of the parasite within the fish is much more prolonged than is the case where the conditions of life are less exceptional.

VIII.—REMEDY.

A natural inquiry following the discovery of the true nature of this parasite will be: What remedies, if any, are proposed?

A very effective remedy, and one which suggested itself immediately to Captain Boutelle, he being an enthusiastic lover of the gentle sport of fishing, is to extermi-

nate the pelican. It would, indeed, be a lamentable result of my investigation if that dire calamity should befall the unwitting cause of this peculiar malady. One of the most charming minor effects of the singularly beautiful scenery of Yellowstone Lake to my mind is produced by the presence of these noble birds. I do not think such heroic measures are either called for or advisable. The trout of the lake can never figure as the food supply of a large number of people. Their abundance or scarcity neither raises nor lowers the price exacted of tourists by the hotel association. They are destined to contribute more to sport than utility. A speedy remedy is therefore not necessary.

With the increase in numbers of visitors to the lake will go greater destruction of trout by enthusiastic fishermen. This will probably reduce the number of diseased fish at a more rapid rate than it will that of the healthy ones, and if the precaution be taken not to leave dead fish on the shore, and not to throw them in the water, where in either case they would probably be eaten by the pelican, the chances of the latter's becoming infested with the parasites will be correspondingly lessened. And particularly if the lake be stocked with some other species of fish (of which I think the chub of Heart Lake is most suitable, since it is an omnivorous feeder, and therefore not likely to interfere seriously with the food of the trout, while furnishing the latter with much-needed animal food, and at the same time lessening the chances of the trout's being eaten by the pelican, and since the parasite does not develop in the chub) a lessened parasitism of the pelican would result; and with fewer parasites in the pelican would go a diminution in the number of ova disseminated in the water, and consequently a lessening of parasitism in the trout.

It is probable, also, that the presence in the lake of some fish which would form a part of the food of the trout would result in imparting a more vigorous constitution to the latter and make it better able to withstand the strain of excessive parasitism.

At any rate, before a war of extermination is waged against the pelican it would be well to ascertain whether or not *Dibothrium cordiceps* develops in other fish-eating birds. My own investigations have not been extensive enough to enable me to decide this question. Beside the pelican, the only birds of the lake that I had an opportunity to examine were three species of duck, none of them piscivorous, one hawk, one heron, and three gulls. In one of the latter I found a *Dibothrium* bearing some resemblance to the trout parasite, but evidently a distinct species.

WASHINGTON AND JEFFERSON COLLEGE, *January* 1, 1891.

EXPLANATION OF FIGURES.

The following letters have the same significance in relation to all the figures where they are used.

c. cuticle.	*p. v.* peripheral vessels.	*ov.* ova.
b. bothrium.	*m. v.* marginal vessel.	*P.* cirrus.
l. m. longitudinal muscles.	*a. v.* aquiferous vessel.	*P'.* cirrus bulb.
c. m. circular muscles.	*vit.* vitellaria.	*d.* vas deferens.
f. v. fibro-vascular layer.	*o.* ovary.	*t.* testes.

Drawings by the author.

PLATE CXVII.

Figs. 1 to 14. Larval stage of *Dibothrium cordiceps* Leidy, from peritoneal cavity and muscular tissues of the trout (*Salmo mykiss*).

Fig. 1. Sketch of head from life, marginal view, lateral of body, from muscular tissue of host; after lying in water three or four hours this specimen measured 34 centimeters in length and 2.5 millimeters in breadth, nearly linear, × about 12.

Fig. 2. Head of specimen from flesh of host, marginal view of head, lateral of body, alcoholic, × about 12.

Fig. 3. Same view of another specimen, alcoholic, × about 12. Lateral view of same specimen shown in Fig. 8.

Fig. 4, 5, and 6. Sketches from life showing some of the diverse shapes assumed by the head and neck of a living worm, each magnified about 12 linear diameters.

Fig. 7. Head and neck of an alcoholic specimen, × about 12.

Fig. 8. Lateral view of head, marginal of neck, same specimen as sketched in Fig. 3, × 12.

Fig. 9. Lateral view of head, marginal of neck; large specimen, 35 centimeters in length, from flesh of host, alcoholic, × 12.

Fig. 10. Median segment of same specimen, × 12.

Fig. 11. Anastomosing vessels of water-vascular system, middle of body, compressed, sketch from life.

Fig. 12. Water-vascular system, posterior end of large specimen, compressed, sketch from life.

Fig. 13. Posterior end of another smaller specimen, compressed, sketched from life; *a*, pulsating vessel; *t. p.*, terminal pore.

Fig. 14. Posterior end of large specimen, alcoholic, × 12. The emargination is sometimes deeper and sometimes not so deep as this.

Figs. 15 to 34. Adult stage of *Dibothrium cordiceps* Leidy, from intestine of the white pelican (*Pelecanus erythrorhynchus*).

Figs. 15, 16. Marginal view of head, lateral of neck of two different alcoholic specimens, × about 15 and 24, respectively.

PLATE CXVIII.

(Adult stage of *Dibothrium cordiceps* Leidy, intestine of white pelican.)

Fig. 17. Marginal view of head, lateral of neck, alcoholic, × about 24. Same specimen as shown in next figure.

Fig. 18. Lateral view of head of specimen figured in No. 17.

Fig. 19. Lateral view of head of another specimen, × 15, alcoholic.

Fig. 20. Segments of body towards anterior end, alcoholic, ventral surface, × 4.

Fig. 21. Antero-median segments, ruffled margin, dorsal surface, alcoholic, × 4.

Fig. 22. Median segments of small fragments, alcoholic, × 12.

Fig. 23. Mature segments from large specimen, alcoholic, × about 5.

Fig. 24. Longitudinal section, near median line, parallel to margin of strobile; the uterine walls have been absorbed and the ova lie in masses; the segmented appearance of the body is here shown to be only superficial.

Fig. 25. Transverse section through cirrus bulb, highly magnified; *a*, retractor muscles of cirrus.

Fig. 26. Transverse section through beginning of vagina, showing the enlargement of that organ near the vaginal orifice into a seminal receptacle, highly magnified.

Fig. 27. Transverse section of mature segment showing the different layers of the body.

PLATE CXIX.

(Adult stage of *Dibothrium cordiceps* Leidy, intestine of white pelican.)

Fig. 28. Diagrammatic sketch of mature segment, showing relative position of genitalia, etc.

Fig. 29. Ovum as seen in a thin section of a mature segment; the knife has cut away a part of the shell exposing the granular contents collected into spherical masses, highly magnified.

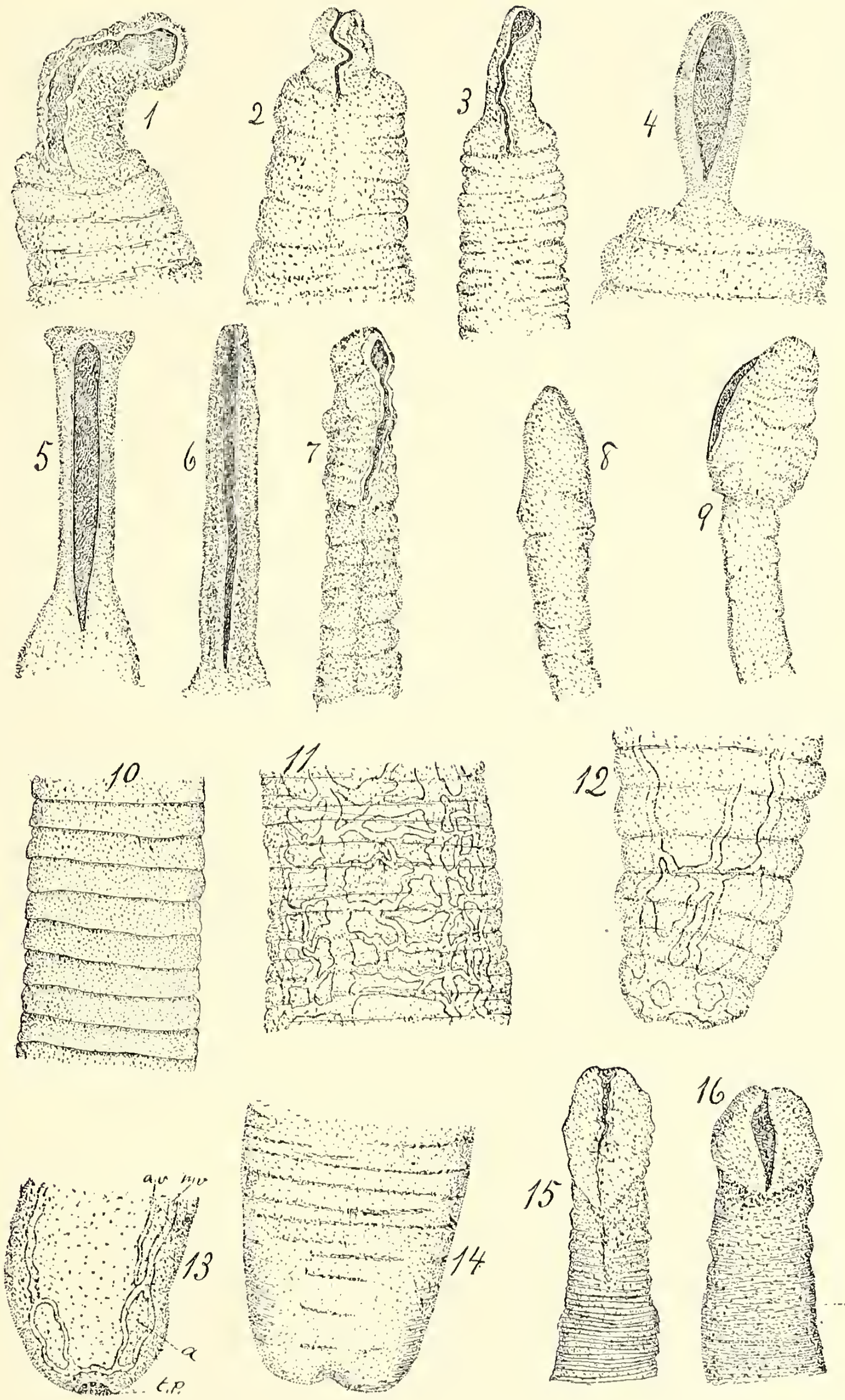
Fig. 30. Diagram of female generative organs, from ventral side; *v. d.*, vitelline duct.

Fig. 31. Section of vagina, highly magnified, showing ciliated interior.

Fig. 32. Portion of transverse section of segment, highly magnified; *Par.*, parenchyma of inner core of body.

Fig. 33. Longitudinal median section, parallel to the margin, through cirrus bulb, uterus, vagina, etc.

Fig. 34. Transverse section of head; *n*, nerve ganglia, a row of which extends across the section from the inner margin of one marginal vessel to the other. The heavy stippling represents the cut ends of longitudinal muscles; *s. c.*, subcuticular longitudinal fibers particularly well developed in the bothria.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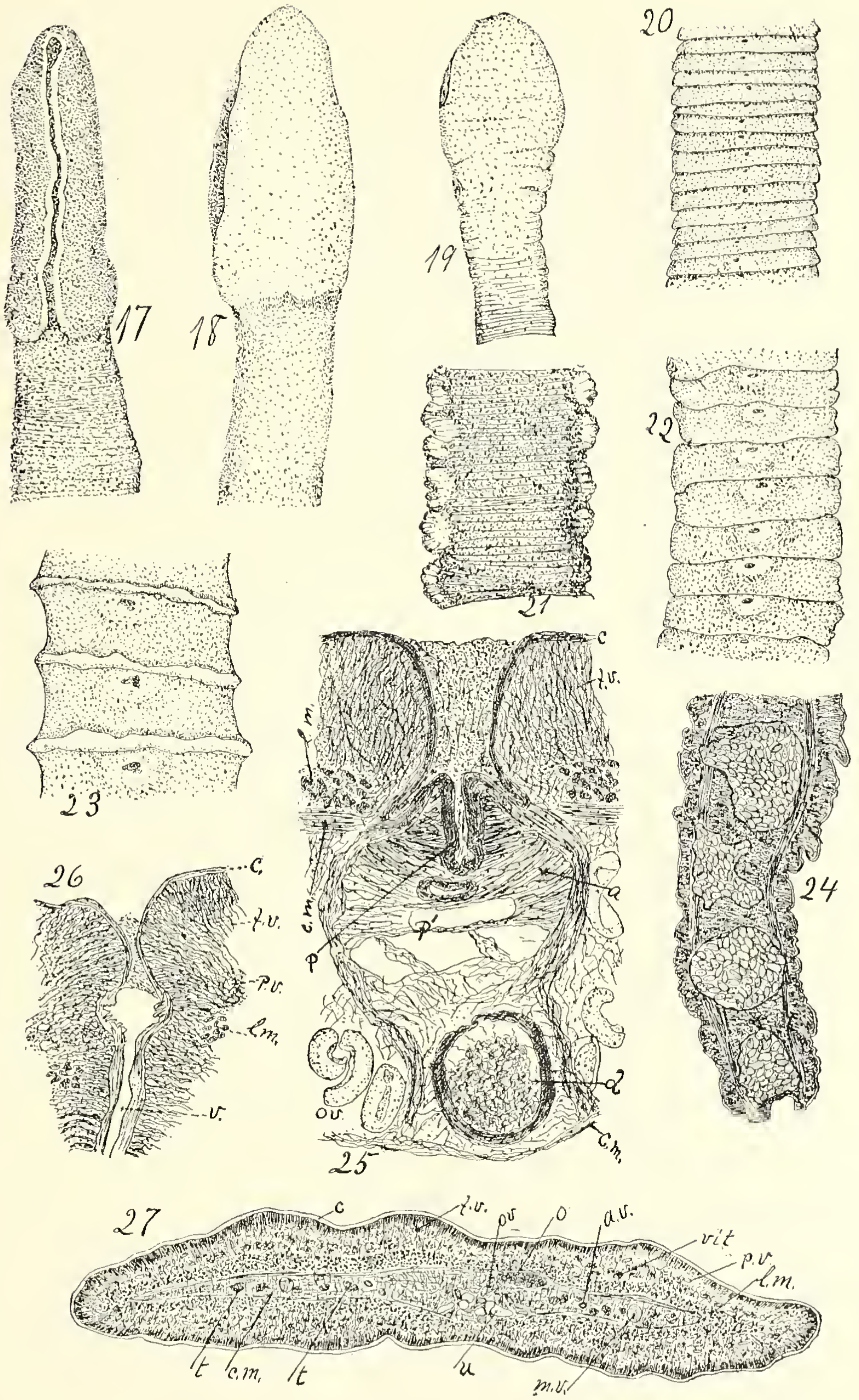
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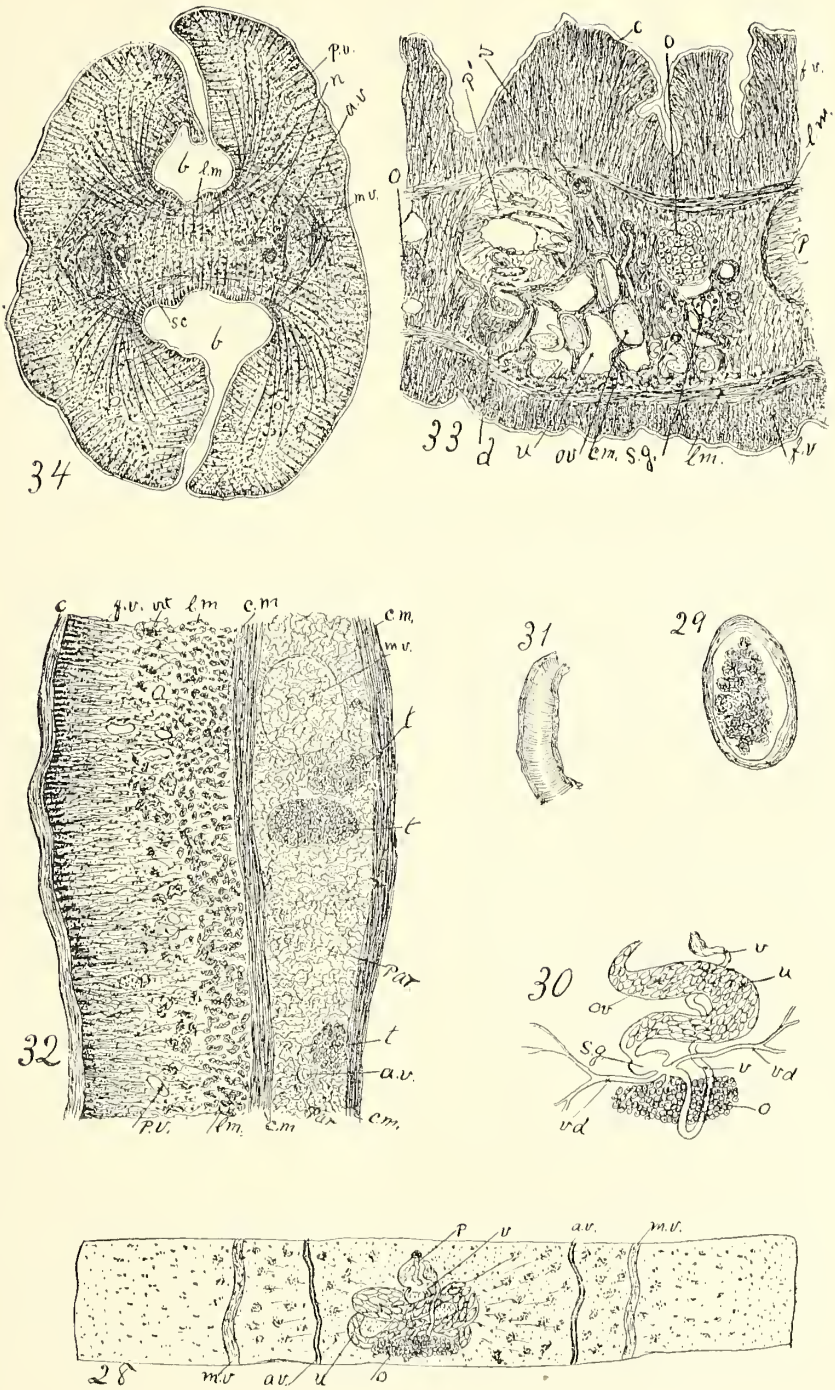


18.—NOTICE OF THE OCCURRENCE OF PROTOZOAN PARASITES (PSOROSPERMS) ON CYPRINOID FISHES IN OHIO.

BY EDWIN LINTON.

(With Pl. cxx.)

Three small Cyprinoids, *Notropis megalops*,* Pl. cxx, Fig. 1, each with several more or less spherical cysts on the exterior of the body, were submitted to me for examination in September, 1890, by the U. S. Fish Commission. The fish were taken in Black River, Lorain County, Ohio, by Mr. L. M. McCormick, of Oberlin College, Ohio, September 1, 1890. In a letter accompanying the specimens, and dated September 10, 1890, the following data are given:

The fish were taken about 6 miles from the lake (Erie) just above an old mill-dam. The water was very shallow and quite warm, the bottom gravelly with a thin layer of mud. Besides the Cyprinoids there were taken in the same locality *Noturus miurus*, *Catostomus teres*, and *Moxostoma macrolepidotum*, and in the rapid water, just below the dam, *Ictalurus* and *Roccus*. The Cyprinoids appear to be the only fish affected by this parasite.

The parasitized fishes are 47, 56, and 57 millimetres in length respectively, exclusive of the tail fin.

No. 1 has two small globular masses 2½ millimetres in diameter on the nose in front of the nasal pores, one on the under side of the head below the right eye, one at the base of the dorsal fin on the right side, and one at the base of the caudal fin on the left side near the ventral edge of the fin. These are all about the same size, and have the appearance of small globular cysts lying beneath the cuticle. Their color is white, with minute patches of black pigment belonging to the skin of the host.

In No. 2 there is a botryoidal cluster made up of about six subspherical cysts at the base of the tail fin on the left side and extending from the dorsal to the ventral edge of the fin. This mass is about 7 millimetres long and 3 millimetres wide. The shorter diameter is in the direction of the anteroposterior axis of the host. On the right side there is another mass similarly situated, and composed of five cysts and a sixth placed a little below the others. The component cysts are from 2 to 3 millimetres in diameter.

A view of the right side of No. 3 is given in Pl. cxx, Fig. 1. This is the most seriously parasitized fish of the lot. There are the following cysts and clusters of cysts: A cyst on the tip of the nose, a cluster of three cysts on the under side of the head

* I am indebted to Dr. D. S. Jordan for the identification of this minnow.

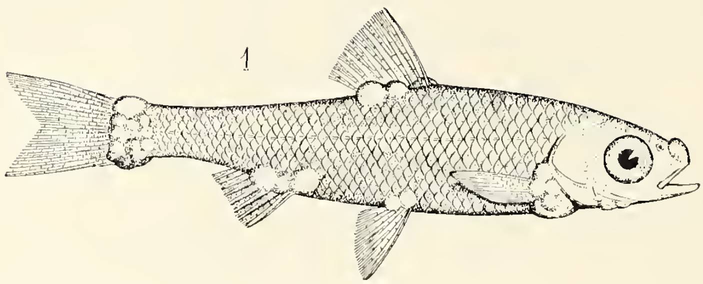
beneath the eye, a cluster of five cysts in front and at the base of the right pectoral fin, two at the base and in front of the left pectoral fin, one on the back at the posterior edge of the base of the dorsal on the right side, and another smaller one a little in front of this one, one on the left side near the anterior edge of the base of the dorsal, two at the base of the right ventral, a cluster of five at the base of the anal fin mainly on the right side, a corrugated mass made up of several cysts on the right side at the base of the caudal fin. This mass is 5 by 7 millimetres in its two diameters and the epidermis over its lower half is dark-colored. On the left side there is a smaller mass at the base of the caudal fin. It is more deeply immersed in the tissues of the host than the other. The epidermis of this fish is marked in several places with dark purplish blotches.

Each of the three fishes is in fair condition. When a cyst was broken open a milky fluid escaped and the wall of the cyst collapsed. A small quantity of the fluid contents when subjected to microscopic examination revealed the presence of myriads of psorosperms. These are somewhat top-shaped, one end broadly rounded and slightly flattened, the other tapering to a point. Their dimensions are about as follows: Length 0.017 millimetre, breadth 0.01 millimetre, thickness 0.006 millimetre. The outline presented by the edge differs from a side view only in being a little narrower. There is, however, a low ridge on the margin, which may be seen when an individual is turned on its edge, but which is not visible as such in a side view. A cross section of one at its thickest part would be a broad ellipse. They are transparent, or nearly so. The walls are thick and strong, and resist the action of both sulphuric acid and caustic potash for a long time. They do not exhibit any tendency to change their shape or capacity with either of the above reagents or with glycerine or acetic acid. The protoplasmic contents of these thick-walled cells appear, in most cases, to be evenly and finely granular. I was unable to distinguish anything corresponding to the twinned vesicles or polar capsules characteristic of these problematical organisms, although the specimens when placed in caustic potash or sulphuric acid become quite transparent and the thick walls are sharply defined. Specimens which were left for several days in dilute sulphuric acid showed no sign of disintegration. The protoplasmic contents, however, had disappeared or were represented by a few granular bodies. What appeared to be a median transverse partition was made out in many individuals in lateral view. An ill-defined mass near the smaller end was present in many (made visible when treated with caustic potash) which may be the beginning of the polar vesicle. No evidence of protractile threads was found.

A cyst was stained with Beal's ammonia carmine, mounted in paraffine, and cut into sections. The cyst was allowed to remain in the staining fluid for several days. The walls of the cyst and a granular protoplasmic material within were deeply stained. The psorosperms were not in the least affected by the staining material. The wall of the cyst is composed of connective tissue, is rather thin, and indistinguishable from the deeper layers of the dermis. All the cysts lay immediately beneath the skin. Scales appeared to be absent from the surface of the cyst in most cases, although a few were observed quite loosely attached on one of the larger clusters. Numerous pigment patches are scattered over the surface of the cysts. The sections showed the cyst to be packed with psorosperms and with granular protoplasm, the latter for the most part lying near the wall of the cyst. There is no apparent order of arrangement

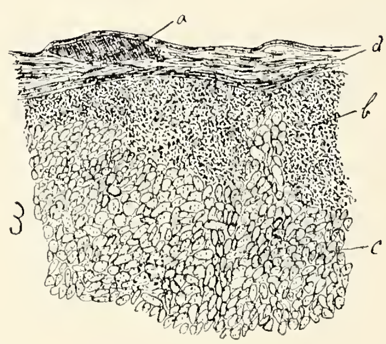
PLATE CXX.

1



2

3



PROTOZOAN PARASITES OF MINNOW.

of the psorosperms. In the sections they are evidently undisturbed and lie as they did in the cyst. They appear to lie in all positions. Edge, side, and end views are presented by individuals lying side by side.

These cysts differ from those found on the short minnow (*Cyprinodon variegatus*) in the absence of connective tissue and calcareous bodies in their substance. They agree closely with those described by Zschokke from *Coregonus fera* of Europe. The psorosperms, however, appear to be different. I am unable to determine from the material at hand whether the absence of polar vesicles is to be interpreted as a specific character or simply due to the immature condition of the psorosperms. The real nature of these peculiar forms is as yet little understood and their life history is not known.

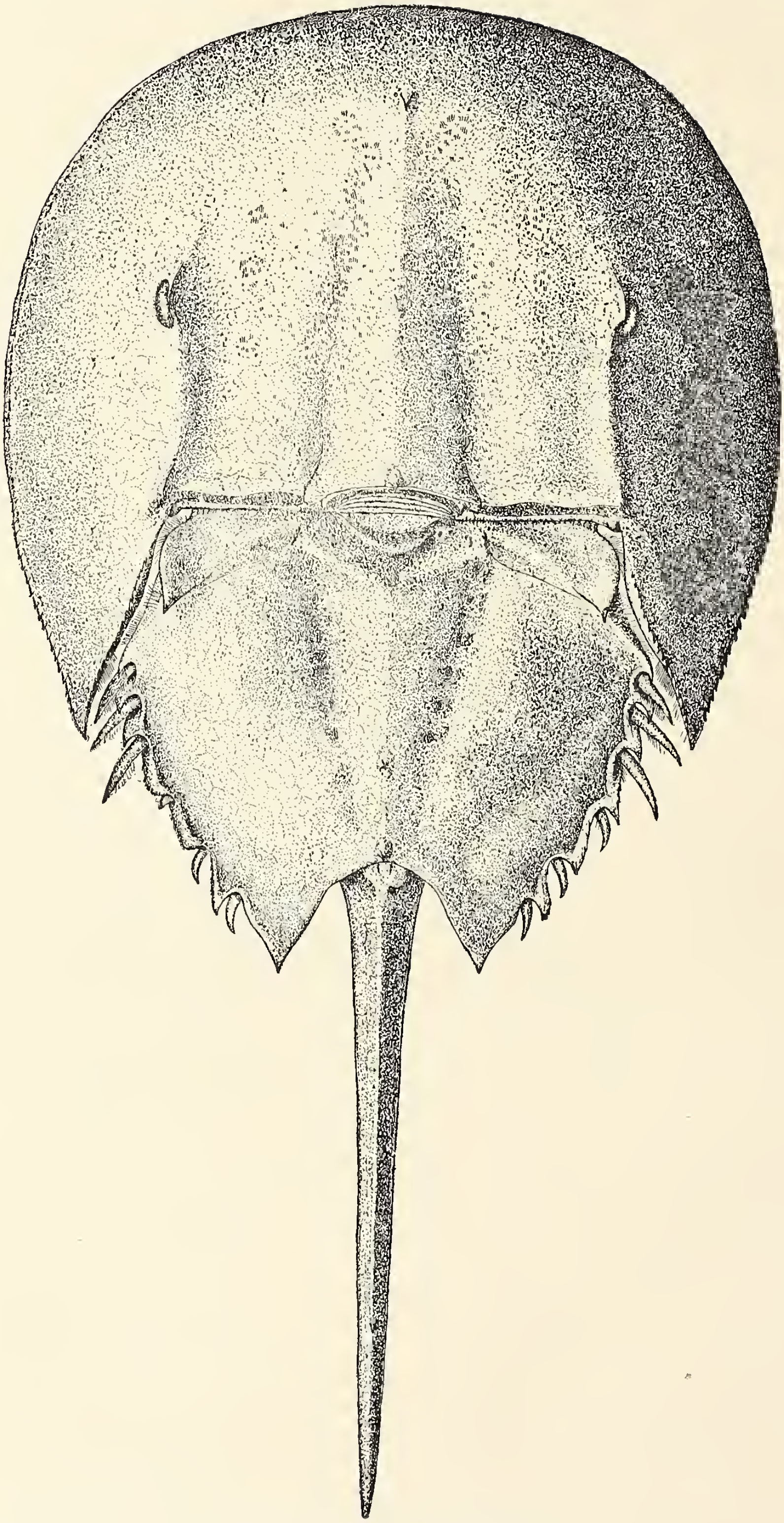
A list of the more important contributions on the psorosperms is given in an article by the author entitled "On certain Wart-like Excrescences occurring on the Short Minnow, *Cyprinodon variegatus*, due to Psorosperms." Bulletin U. S. Fish Commission, 1889, p. 99.

EXPLANATION OF THE FIGURES.

Fig. 1. Cyprinoid (*Notropis megalops*) with dermal cysts caused by psorosperms. × 1½.

Fig. 2. Psorosperms liberated from cysts and highly magnified. *a*, side view of specimen in caustic potash; *a′*, same more highly magnified; *b*, view of edge; *b′*, same more highly magnified; *c*, specimen treated with sulphuric acid.

Fig. 3. Portion of thin section of cyst. *a*, pigment spot; *b*, granular protoplasm; *c*, psorosperms; *d*, wall of cyst and dermis. × about 150 diameters.



THE KING CRAB (*Limulus polyphemus*).

Four-fifths natural size.

19.—NOTES ON THE KING-CRAB FISHERY OF DELAWARE BAY.

BY HUGH M. SMITH.

(With Plates CXXI–CXXIII.)

INTRODUCTORY.

The fishery for king-crabs, while not primarily intended to provide a food product, nevertheless indirectly contributes to that result by furnishing a simple yet efficient fertilizer for use on land the natural vitality of which is low or has been exhausted. The king-crab, therefore, notwithstanding it has no commercial value for edible purposes,* is an important economic factor both to fishermen and farmers, and its capture becomes an industry of no little consequence to the community, in addition to the inherent interest which it possesses for those whose attention is directed toward the commercial fisheries.

While farmers and others in many of the States on the Atlantic seaboard, from Massachusetts to Florida, utilize small numbers of the crabs for fertilizer, and occasionally as food for poultry and swine, it is only in Delaware Bay that the capture of the animal can be said to constitute a well-defined industry, and it is only there, so far as known, that special forms of apparatus have been devised and employed for taking the crabs.

OBSERVATIONS ON HABITS, REPRODUCTION, ETC.

The king-crabs are chiefly found on soft sandy or muddy bottoms, where, more or less imbedded, they spend the greater part of their existence. In the colder months they probably retire to the deeper portions of the bay, but what condition of life they then assume is not known. It is chiefly, and almost exclusively, during the breeding season that they approach the shore. The deposition and impregnation of the eggs being accomplished, they rapidly withdraw to deeper water and do not usually visit the beaches again in any numbers till the following year.

The breeding season may be said to cover two months, beginning about May 1 and extending to July 1. During this period the crabs seek the sandy shores in pairs, the male riding on the back of the female; sometimes, however, a female will

*Capt. Charles H. Townsend, of New Haven, states that he has found the king-crab very palatable when steamed, and thinks it equal or superior to any of the common edible crabs.

be attended by two or more males. Reaching the shore, the eggs are deposited above the water's edge in a slight depression in the sand made by the female, and the male extrudes the milt over them. The adults then withdraw to the water; the eggs receive no more attention, and are covered with sand and washed about by the waves. When hatching ensues, the young enter the water to return to the shore again upon reaching maturity.

The abundance of crabs on the shore during any special week or month appears to be largely dependent on the tides. Mr. Howell remarks that the farmers and fishermen take the greatest quantities when the moon is full or in perigee, and the influence of the tides on the movements of crabs has come to be fully realized. The wind is also held to increase or decrease the numbers of crabs, a westerly wind bringing them in abundantly on the New Jersey coast, while an easterly wind is most favorable on the opposite side of the bay, upon the shores of Delaware.

THE FISHING SEASON.

The season during which king-crabs are taken varies somewhat from year to year, owing to hydrothermal and other conditions, but ordinarily begins about May 1 and continues till June 15 or July 1, in New Jersey. In Delaware it is somewhat longer, and often extends to August 1. As already explained, the fishing season coincides very closely with the breeding season.

THE FISHING CENTERS IN NEW JERSEY.

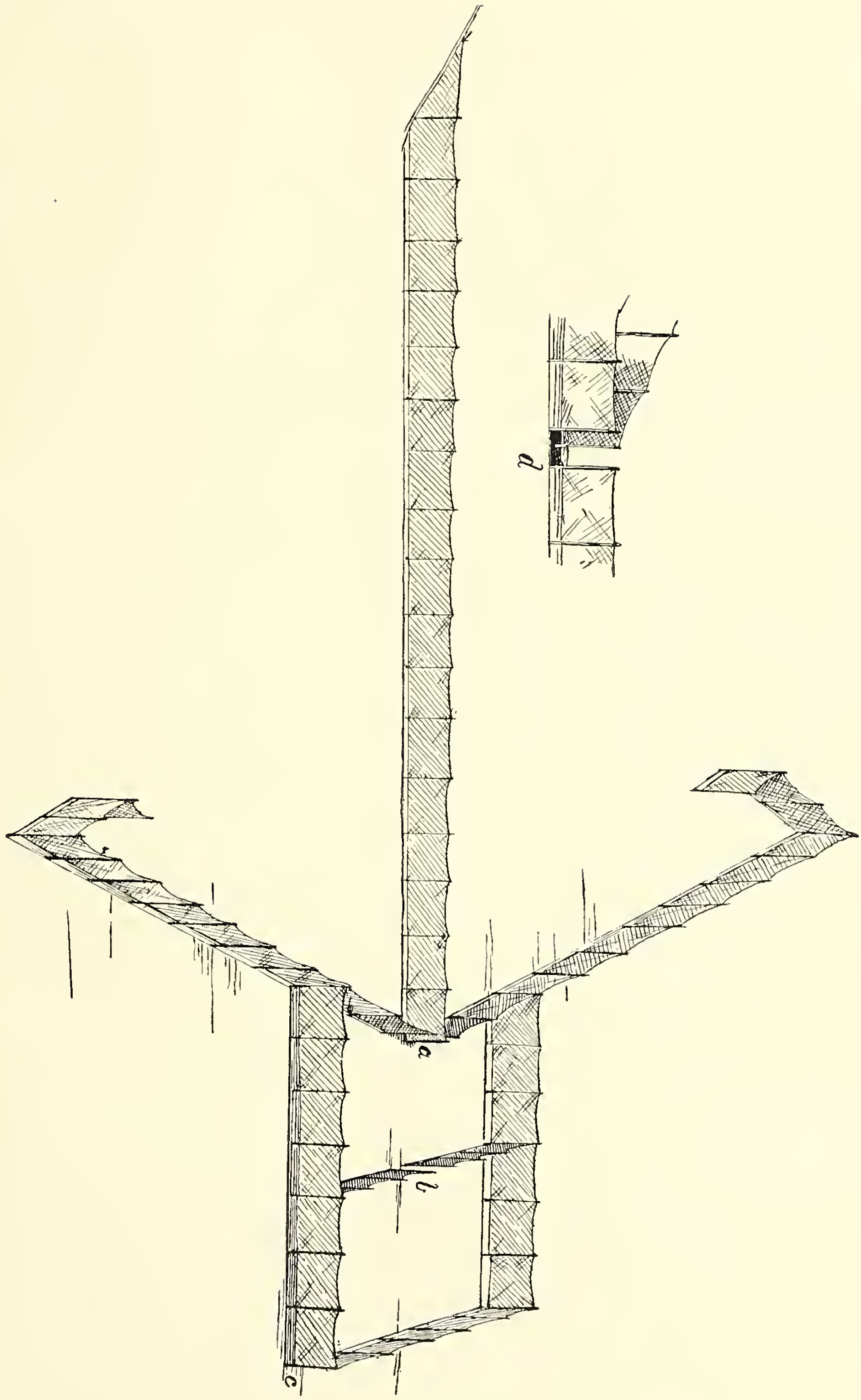
The most northern point on Delaware Bay at which crabs are taken is Heislerville, between which and Cape May Point, a distance of 20 miles, the crabs are sought at Ewing Neck, West Creek, East Creek, Dennisville, Goshen, Dias Creek, Green Creek, Fishing Creek, Town Bank, and one or two other minor settlements. About seven-eighths of the entire catch is made between Dennisville and Fishing Creek, inclusive, and about three-fourths of the yield is taken at Goshen, Dias Creek, and Green Creek, in which places the catch in 1890 was, in round numbers, 335,000, 410,000, and 411,000 crabs, respectively. At the extremities of the stretch of coast above defined the output was much smaller, varying from 10,000 to 30,000 at Town Bank, Heislerville, etc.

APPARATUS AND METHODS.

While considerable quantities of crabs are caught by hand on the shores of Delaware Bay, where they go to deposit their spawn, the growing scarcity of the species has more and more demanded the employment of apparatus of capture by means of which the individuals that are in the water adjacent to the shores may also be secured. As yet no traps have been employed on the shores of the State of Delaware, but such appliances have been set in New Jersey waters for a number of years, and their use is becoming more extensive each year.

Two forms of apparatus are in rather common use along the New Jersey shore between Cape May Point and Heislerville. One resembles some types of pound-nets, but the other is, so far as known, entirely unlike anything else used in the waters of the United States and is designed for and especially adapted to this fishery.

Regarding the pound-nets used in this fishery, Mr. Earll says:



POUND NET FOR CATCHING KING CRABS AND FISH.

a, entrance to outer crib; *b*, entrance to inner crib or fish pound; *c*, position of slats around bottom of pound net; *d*, section at entrance to outer crib.

In 1880 there are nine of them on the flats along the shore, some having 2 or 3 feet of water at low tide, while others are entirely dry. They differ considerably from the pound-nets of other portions of the coast. The leader is about 50 fathoms long, and in the place of the fore-bay are two wings, each 25 fathoms in length. The pound proper or bowl is divided into two compartments, the first being intended for king-crabs (*Limulus polyphemus*) that are taken in enormous numbers during the early summer. The second compartment is connected with the first by means of a funnel-shaped opening large enough to allow the fish to enter, but too small to admit the crabs. The lower part of the pound is made of stakes imbedded in the mud and extending a foot or more above it. To these the netting is attached, the object being to keep it above the crabs that would otherwise destroy it.*

Mr. Howell states that most of the pound-nets now used have bowls or "pounds" only for crabs, and that but few fish have been taken in late years in the nets provided with two compartments, although formerly considerable quantities of squeteague and goody were secured.

The stakes which form the framework for these pounds are 8 to 10 feet long and 4 to 6 inches in diameter. They are located 4 to 6 feet apart. To the bottom of the stakes, constituting the "hedge," boards 1 inch thick are nailed to the height of a foot or more; the bottom of the bowl, and the sides to the height of 1 to 2½ feet, are formed in the same way, as mentioned by Mr. Earll. The door to the first bowl is from 18 to 24 inches wide on each side of the leader; the funnel-like entrance to the second bowl, when one exists, is much narrower, and only a few crabs pass through it. The netting consists of either wire or twine.

The cost of such an apparatus depends somewhat on the length of leader and size of bowls. The most expensive form operated in recent years was probably worth not more than $75, from which amount to about $25 every intermediate value is represented.

This form of net is employed where the tide leaves the "pound" dry or fully exposed at low water. Both boats and wagons are used in tending the nets; the wagons are considered more convenient and are more extensively employed. The crabs are taken from the nets with pitch-forks, or with a crab-spear consisting of a single piece of sharp-pointed metal mounted in a long handle.

The catch varies with the year, month, and tide. In 1888 the catch per tide was from 25 to 2,000 crabs to each net, or from 5,000 to 60,000 crabs per season. In 1890 the average catch was considerably smaller, taking the entire shore into consideration.

The weir, or "stake net" as it is here called, is very different from the pound-net just described, although both have some parts in common, as will be seen by consulting the accompanying plates. It consists essentially of poles or stakes driven into muddy or sandy bottoms, so as to form a leader or "hedge," wings, and a bowl or "pound." The poles constituting the bowl are 8 to 10 feet long and 2 to 4 inches in diameter at their larger ends and 1 to 1½ inches in diameter at their smaller extremities. For the wings and leader, poles from 3 to 6 feet long are employed. The poles are placed from 1½ to 3 inches apart to permit the sea to wash through.

The bowl is somewhat semicircular in shape, the extremities of the brush-work joining the wings about midway their length. Its capacity is encroached upon by the leader and the door or entrance to the pound, which is the most important feature of the apparatus. It consists of a wedge-shaped platform of boards fitting into the space between the wings as they approach the leader. The platform is inclined at a gentle

* The Fisheries and Fishery Industries of the United States, Section II, p. 397.

angle and is about 5 feet long, projecting about 1 foot over a support, as shown in the figure. It is important that the pitch of the platform shall not be too great and that the floor shall not be too smooth, otherwise the crabs can not or will not walk on it. The floor of the bowl is made of cheap boards to prevent the crabs scratching holes in the mud and loosening the poles.

The cost of such a weir is from $12 to $20. The catch is about the same as in the other form of apparatus.

Such traps are mostly made by farmers who have woodland near the shore on which to draw for poles, of which, as may be readily understood, a large number is required. They are usually set in a cove on muddy bottom. One person in a boat can fish from two to four such weirs on one tide. When they are set on a sandy beach, as is sometimes the case, they are fished with a horse and wagon, and one person can then tend more than the number stated. The crabs are removed to the boats or wagons in the manner already mentioned.

The resemblance of the shape of this weir to the general outline of a king-crab is worthy of mention.

DECREASE IN THE ABUNDANCE OF CRABS.

In 1880 Mr. Richard Rathbun wrote as follows concerning king-crabs in Delaware Bay:

> They are very much less abundant now than formerly, on account of so many having been caught from year to year for use as a fertilizer. It would appear as though a few years more of indiscriminate capture would result in their being entirely exterminated from the region.*

This note of warning was well-timed, as shown by the greatly reduced catch in recent years, although more persons and larger quantities of apparatus have been employed. The yield in 1880, 4,300,000 crabs, was more than double that of each of the years 1887, 1888, 1889, and 1890.

The diminution in the abundance of the crabs is no doubt chiefly due to the unfortunate practice of capturing them during the spawning season, usually before the eggs are deposited or impregnated.

It seems probable that before long the decimation will become so pronounced that the profitable prosecution of the fishery will be impossible; then it is hoped that the employment of the destructive forms of apparatus will be discontinued and the crabs given an opportunity to multiply unrestrictedly for a few years at least, although of course it is expected that the farmers will continue to utilize such individuals as are found on the beaches and can be taken by hand.

The actual extent of the diminution in numbers can perhaps be better appreciated by an appeal to figures. In 1887, in New Jersey, the total catch was 1,296,000 crabs; in 1888 the yield was 1,502,000 crabs, whereas, other things being equal, the increase in the apparatus should have resulted in a catch of about 2,275,000; in 1890 the number taken was 1,674,670, whereas, compared with 1888, it should have been about 3,415,000. Since much the larger part of the catch is made with the pound-nets and weirs, it seems legitimate to make these deductions.

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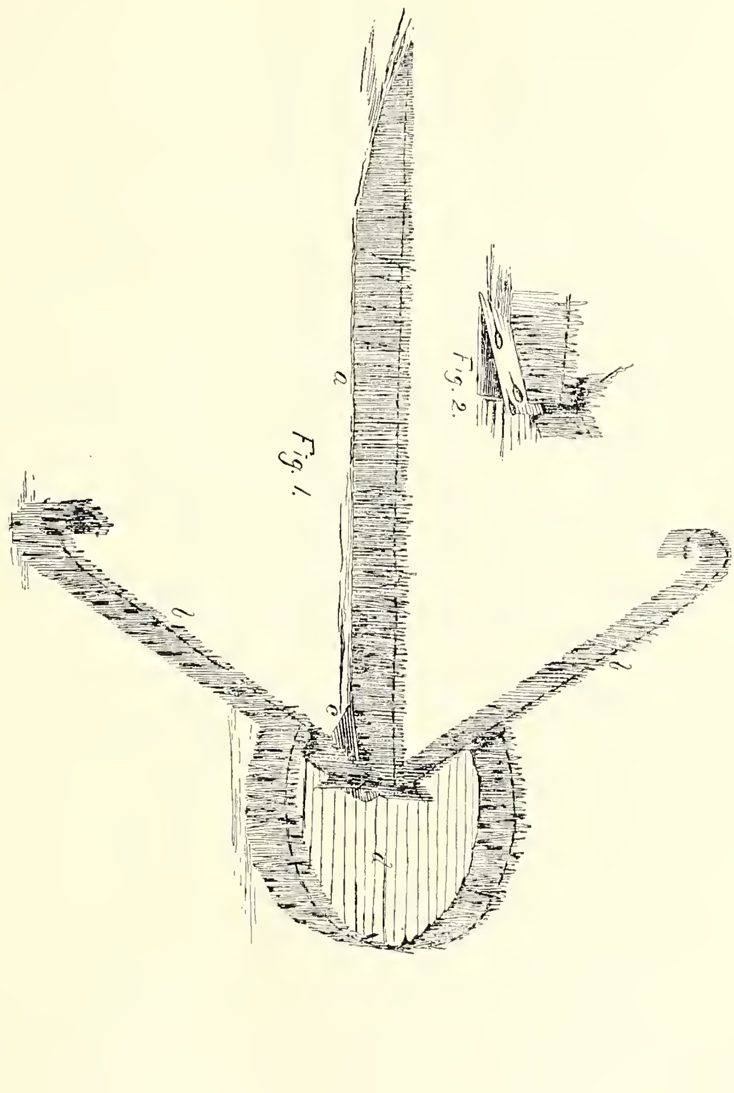
* The Fisheries and Fishery Industries of the United States, section I, vol. 1, p. 830.



STAKE WEIR FOR KING CRABS.

FIG. 1. The weir. *a*, leader; *b b*, wings; *c*, entrance; *d*, flooring and crib.
FIG. 2. Sectional view of entrance to crib, showing inclined platform.

To show the case in a somewhat different aspect, the following comparative table is introduced, giving the percentage of increase in apparatus and the resulting increase in catch for the years 1887, 1888, and 1890:

Year.	Percentage of increase in apparatus.	Percentage of increase in catch.
1888 over 1887	75	16
1890 over 1887	163	28
1890 over 1888	50	11

Numerous instances of a more detailed character might be adduced to show the decrease in the numbers of crabs from year to year, but such cases are not so conclusive as are comparisons of the total yield of the State, owing to the conditions of temperature, etc., which might influence the advent of the crabs to particular sections of the coast, making them unusually abundant in one section and uncommonly scarce in another during one season, and completely reversing the conditions the following year. One noticeable instance, however, may with propriety be given: In 1887 two nets at West Creek, New Jersey, took crabs to the number of about 40,000; in 1890 the same apparatus at the same place yielded only 12,000 crabs.

It can not be denied, as shown by reliable returns, that in some localities there has not only been a maintenance of the supply but even an increase; but the general trend is and has been toward a decrease, and the catch has only been maintained by an increase in the amount of apparatus.

It is worthy of mention that, although no traps or other devices are employed in Delaware, the decline there has been quite as pronounced as on the opposite side of the bay, the catch being no doubt influenced by the great drain on the species in New Jersey. The yield in 1880 was 900,000 crabs, and in 1888 only 320,000.

THE OUTPUT IN NEW JERSEY.

The yield of this fishery during recent years is given in the following table, in which, for purposes of comparison, the catch in 1880 is also shown:

Years.	Number of crabs taken.	Value to fishermen.
1880	3,400,000	$13,600
1887	1,296,000	6,480
1888	1,502,000	7,510
1890	1,664,670	8,030

Although there has been a small actual yearly increase since 1887, this, as stated elsewhere, is to be attributed to the employment of greater quantities of apparatus.

THE FISHERY IN DELAWARE.

The number of localities on the shores of Delaware at which king-crabs are taken is small, and the fishing centers are mostly adjacent to fertilizer factories. As stated elsewhere, there is no special fixed apparatus used in the king-crab fishery of Delaware. The fishery is confined to the shore and the shallow water adjacent thereto, and is prosecuted from boats and from wagons, according as the men are regular

fishermen or farmers. The fishing is chiefly carried on from Barker's Landing and Bower's Beach and in the vicinity of those places.

At Barker's Landing, where the fishing is mostly done for a factory, the business in 1888 was followed from six "lighters" or skiff-like boats, 12 to 16 feet long, and operated by eight men, all told. When the wind is "offshore," these boats go up and down the shore and secure crabs on the beaches. Two large scows, 42 and 30 feet long, respectively, are sent out to bring the crabs from the lighters to the factory, so that time may not be lost by the boats engaged in catching the crabs.

At Bower's Beach there were only four professional crab fishermen in 1888, but they were joined by thirty-five farmers, farm hands, and wood-choppers. The fishermen employed 25-foot scows; the farmers, farm hands, wood-choppers, and other semi-professional fishermen at the place made half of their catch in boats and half in wagons. In addition to the quantities sold to be made into fertilizer, about 25,000 crabs are annually utilized as food for hogs. A portion of the catch is also disposed of to vessels sent out by factory operators in New Jersey. At Banckenburg Creek, 1½ miles below Bower's Beach, there is a small factory; eighteen men, using nine scows, were employed there as fishermen in 1888. In the same locality, about fifteen farmers regularly drive down to the beach in their wagons and get crabs for their own use or for sale to the factories.

The average annual catch to a scow in recent years has been about 7,000 crabs. The farmers and others do not usually take more than a few thousand each.

THE OUTPUT IN DELAWARE.

Accurate figures for this fishery in Delaware covering the year 1890 are not available, but the catch has been estimated at 275,000 crabs. The yearly decline since 1880 has been marked, and is no doubt suggestive of what would result in New Jersey were the annual increase in apparatus discontinued.

Years.	Number of crabs.	Value to fishermen.
1880	900,000	$2,700
1887	341,000	682
1888	320,000	640
1890	275,000	550

THE FERTILIZER FACTORIES.

Three factories designed for preparing king-crabs for fertilizer were in operation on Delaware Bay in 1887 and 1888. Two of these were in Delaware and one in New Jersey. The buildings were comparatively inexpensive frame structures, with a combined value of $4,100. The factory hands numbered eighteen.

The factories in Delaware were located at Banckenburg Creek and near Barker's Landing. The one at the former place was quite small, the building being only 16 feet square. Beneath was a furnace, by means of which the crabs were dried. About 200,000 crabs are the usual annual quota of this factory. The factory building near Barker's Landing was 24 by 60 feet in size. It was provided with a steam-mill in which the crabs were ground while green and then mixed with sodium sulphate

(Na_2So_4). Some seasons as many as 100,000 crabs are utilized, but in 1887 and 1888 only 50,000 and 30,000, respectively, were used. The scrap is sold to farmers, and also to regular fertilizer dealers by whom it is further treated. Nearly the entire output is sold in Delaware and other States of the "Peninsula," at from $25 to $30 per ton.

The factory in New Jersey, situated at West Creek, was larger than either of those in Delaware, and was valued at $2,000. The number of crabs handled is from 1,000,000 to 2,000,000 annually; and in 1887 and 1888 was about 1,300,000, representing almost the entire catch of the State, in addition to small quantities from Delaware. The sales of fertilizer prepared here are mostly local.

The approximate number of tons of crab fertilizer prepared in Delaware Bay was 740 in 1887 and 835 in 1888. These figures include the scrap manufactured at the factories ("cancerine") and also the crude product used by farmers and others on their land. At the ruling market prices, the fertilizer had a value of $15,800 in 1887 and $17,600 in 1888.

In 1890, 275,000 crabs were sent to Billingsport, New Jersey, and 225,000 to Baltimore, Maryland, from points on the New Jersey shore, to be used in the preparation of complex fertilizers. Almost the entire remaining portion of the catch was sold to the West Creek factory.

PRICES OF CRABS.

In 1880 the average value of crabs in New Jersey was given as $4 per thousand and in Delaware as $3 per thousand. In recent years the tendency has been toward an increase in price in New Jersey, owing to the growing scarcity of the crabs and the competition among the fishermen; while in Delaware, where the demand is less and the supply comparatively greater, the price has declined. Much the larger part of the catch in New Jersey during the past four years has been disposed of at $5. In Delaware, on the other hand, about $2 has been the ruling price.

STATISTICAL DATA.

Complete statistics of this industry in Delaware Bay are not available for a later year than 1888, when an investigation of this subject was made by the writer in connection with a general canvass of the fisheries. The figures obtained as a result of that inquiry are embodied in the following table, showing the extent of the industry in 1887 and 1888:

Year.	Regular fishermen.	Factory hands.	Value of factories.	Boats.		Pound-nets and weirs.		Crabs taken.		Scrap produced.	
				No.	Value.	No.	Value.	No.	Value to fishermen.	Approximate number of tons.	Approximate value.
1887	96	18	$4,100	42	$1,210	41	$561	1,637,000	$7,162	750	$15,800
1888	127	18	4,100	60	1,555	72	964	1,822,000	8,150	835	17,600

The following additional tabular statement has been prepared from information kindly furnished by Mr. E. S. Howell, of Dias Creek, New Jersey, upon whose fund of knowledge on fishery subjects the writer has had frequent occasion to draw:

Statement of the extent of the king crab fishery in New Jersey in 1890.

Locality.	No. of fishermen.	No. of horses employed.	No. of boats used.	Pound-nets and weirs.			The output.				
				No.	Value.	Character of shore on which located.	No. of crabs taken in nets.	No. of crabs taken by hand.	Total number of crabs taken.	Value.	Average value per thousand.
Heislerville	2			3	$36.00	Sand	7,500	25,000	32,500	$130.00	$4.00
Ewing Neck	2			3	34.50	Sand and mud.	7,200	20,000	27,200	108.80	4.00
West Creek	3		2	2	40.00	Sand	12,000	19,500	31,500	157.50	5.00
East Creek	3		4	13	243.75	Mud	65,000	3,000	68,000	323.00	4.75
Dennisville	3		5	20	380.00	...do	120,000	5,000	125,000	625.00	5.00
Goshen	4		4	6	82.50	Sand and mud.	27,450	306,600	334,050	1,586.74	4.75
Dias Creek	20	15	5	25	643.75	Sand	250,000	159,600	409,600	2,048.00	5.00
Green Creek	20	15	5	20	1,121.00	...do	401,000	10,000	411,000	2,055.00	5.00
Fishing Creek	12	11		12	420.00	...do	180,000	3,000	183,000	824.50	4.50
Town Bank	2	2		2	20.00	...do	7,200	2,500	9,700	38.80	4.00
Elsewhere	2		2	2	20.00	...do	3,120	30,000	33,120	132.48	4.00
Total	73	43	27	108	3,041.50		1,080,470	584,200	1,664,670	8,029.82	4.82

Mr. Howell says that, in addition to the regular fishermen mentioned in the table, about 150 men and boys along the coast take crabs when they are most plentiful. Their catch is included in the summary.

20.—REPORT UPON A COLLECTION OF FISHES MADE IN SOUTHERN FLORIDA DURING 1889.

BY JAMES A. HENSHALL, M. D.

The months of February, March, and April, 1889, were spent by the writer in making an ichthyological exploration of the southern coast of Florida, in conjunction with the U. S. Fish Commission schooner *Grampus*, which was then at work upon the neighboring red-snapper grounds of the Gulf of Mexico.* A large seine boat and a dory belonging to that vessel were assigned to this investigation, and the necessary fishing appliances and camping utensils were also provided, chiefly from her outfit. The party consisted, besides the writer, of a pilot (Capt. William Pent, of Key West) and a seaman and the cabin boy from the schooner.

We left the *Grampus* at Indian Key February 11, with the intention of first proceeding northward inside of the Florida reefs to Miami, at the upper end of Biscayne Bay, but stormy weather interfering the work was begun in Card's Sound and carried thence through Barnes' Sound and northwestward along the Gulf coast as far as Tampa Bay. The *Grampus* was met at Charlotte Harbor March 4, for the purpose of replenishing our supplies, and again at Port Tampa March 29, where the regular shore investigation was concluded April 4. Some seining was, however, subsequently done at the Dry Tortugas and in the vicinity of Key West during the passage to New York.

Nearly all the work was limited to salt water, on account of the remoteness of the fresh-water streams from the shores and their inaccessibility from most places which we visited. We managed, however, to reach a few isolated fresh-water ponds by carrying the collecting outfit overland, but this proved to be a very difficult undertaking in the thickly-wooded section where the attempts were made.

Between Biscayne Bay and Charlotte Harbor practically no fisheries exist. The coast from Cape Sable to Pavilion Key consists of mangrove shores and islands, entirely unsuited to the hauling of large seines. On Estero Bay, just below Charlotte Harbor, there is a small fishing ranch operated by two men, but it is scarcely worthy of notice. At Gordon's Pass and at Marco a little fishing is also done by a few individuals to supply the local demand, but it is not upon a sufficiently large scale to entitle it to recognition from a commercial standpoint.

* Report upon an investigation of the fishing grounds off the West Coast of Florida. By A. C. Adams and W. C. Kendall. Bull. U. S. Fish Com., vol. IX, for 1889, pp. 325-349.

The present paper is a record of all the species of fishes collected or observed at each locality visited, together with such field notes respecting them as seem to merit publication. The specimens preserved in alcohol have been examined by Dr. David S. Jordan, and the specific indentifications of the same rest upon his authority. I am also under special obligations to Mr. Louis Rettger, assistant in the museum of the University of Indiana, for the arrangement in order of the species given in the main list. The type series of specimens is contained in the U. S. National Museum at Washington. Partial sets have also been deposited in the museum of the University of Indiana and in the museum of the Cincinnati Society of Natural History.

Two lists are given. The first is limited to those species of which specimens were preserved and subsequently studied by Dr. Jordan and the writer. The second or supplemental list includes the larger species taken and not saved because of their size, and also those which were observed but not captured.

GALEORHINIDÆ.

1. Eulamia limbata (Müller & Henle) (?). Spotted-fin Shark.

San Carlos Pass, west coast of Florida. Teeth very narrow, scarcely serrate; first dorsal, pectoral, and lobe of caudal tipped with black; back dark; belly abruptly pale; a blackish stripe along side below the boundary of the dark area, extending to opposite pectoral; second dorsal very small, as large as anal. First dorsal well behind pectoral. A very young specimen, 20 inches long, too young to be certainly identified.

PRISTIDIDÆ.

2. Pristis pectinatus Latham. Sawfish.

West coast of Florida. Abundant in all bays of the west coast where mud flats occur. I observed schools of young ones feeding in shallow water. They use their "saws" for stirring up the mud or sand of the bottom in order to obtain their food. The motion of the saw is principally a forward and backward one. The young when born are nearly or quite 2 feet long, including the saw, which is about one-third their length. I captured several at Big Gasparilla, with a dip net, in shallow water, from 3 to 5 feet long, by entangling the net in their saws and towing them ashore. I also captured one on a shark line measuring fully 18 feet in length. The large ones frequently become entangled in the nets of fishermen and turtlers and do much damage in that way.

RAJIDÆ.

3. Raja lævis Mitchill (?). Barn-door Skate.

Stump Pass. Several embryos, apparently of this species, although it has not hitherto been recorded from any locality so far south. These embryos were blown into the pass during a southwest gale, and when taken from their egg cases swam around very lively in a bucket of water.

SILURIDÆ.

4. Ailurichthys marinus (Mitchill). Gaff-topsail Catfish.

West coast of Florida. This and the next species are very abundant everywhere in the bays and inlets of Florida, and also ascend the brackish streams. They will take anything in the nature of a bait, dead or alive, from the artificial fly to a chip of wood. They are great nuisances to the angler or fisherman, and, though not a bad food fish, are never eaten. They make a continual grunting, rasping, or croaking noise when caught, and also when swimming. They are taken usually from one-half to 2 pounds in weight.

5. Tachysurus felis (Linnæus). Sea Catfish.

West coast of Florida.

STOLEPHORIDÆ.

6. Stolephorus mitchilli (Cuv. & Val.). Anchovy.

Card's Sound; Barnes' Sound; Key West; Marco; Gordon's Pass; Big Estero Pass. This and the next species are very abundant in most of the inlets and passes of the west coast, coming in and going out with the tide. At Marco or the Gasparillas fisheries for taking and curing anchovies ought to be very profitable if established.

7. Stolephorus browni (Gmelin). Anchovy.

Cape Sable Creek; Cape Romano; Big Gasparilla.

8. Stolephorus perfasciatus (Poey). Anchovy.

Marco Inlet. This anchovy was more abundant at Marco than anywhere on the west coast.

CLUPEIDÆ.

9. Dussumieria stolifera Jordan & Gilbert.

Card's Sound; Barnes' Sound. This beautiful little species, discovered a few years ago at Mazatlan, Mexico, by C. H. Gilbert, is common in the shallow waters of Card's Sound and Florida Bay.

10. Harengula macrophthalma (Ranzani). Pilchard.

Key West. Common along the Florida Keys. It is sometimes used as bait for kingfish (*S. caballa*, *S. regalis*) and other large species.

11. Harengula arcuata (Jenyns). Pilchard. (*Clupea humeralis* Cuv. & Val., *Harengula pensacolæ* Goode & Bean.)

Cape Sable Creek; Marco; San Carlos Pass; Big Gasparilla; Egmont Key. This little herring is abundant at most of the inlets of the west coast, going in and out with the tide.

12. Opisthonema oglinum (Le Sueur). Thread Herring; Sprat.

Big Gasparilla; Egmont Key. Common along the west coast.

ELOPIDÆ.

13. Elops saurus Linnæus. Ten-pounder.

Marco; west coast of Florida. Of this species some very young specimens were obtained representing a larval or leptocephalous form, translucent and elongate, recognizable only by the fin rays and the structure of the jaws.

SYNODONTIDÆ.

14. **Synodus fœtens** (Linnæus). Lizard Fish. (*Synodus spixianus* Poey.)

Key West; Gordon's Pass; San Carlos Pass; Big Gasparilla. This voracious little marauder is common in all of the bays of the west coast.

CYPRINODONTIDÆ.

15. **Jordanella floridæ** Goode & Bean. Jordan's Minnow.

Fresh pond near Myakka River. Common in fresh water throughout the State.

16. **Heterandria formosa** Agassiz.

Fresh pond near Myakka River. This minute species and the next are common in fresh ponds and brackish waters.

17. **Lucania parva** (Baird & Girard). Rain-water Fish.

Card's Sound; Gordon's Pass; Big Gasparilla; Myakka River; Long Boat Key.

18 **Fundulus similis** Baird & Girard. Salt-water Minnow.

Barnes' Sound; Cape Romano; Marco; Big Gasparilla; Gordon's Pass; Myakka River; Stump Pass; Lemon Bay; Sarasota Bay.

At the mouth of Bowley's Creek, in Sarasota Bay, I saw this species congregated in thousands, spawning on the shallow sand bars. Two males would usually head off the female and, one on each side of her, convey her into water only deep enough to cover them, sometimes even forcing her out of the water on the bare sand. The males pressed close to the side of the female, their caudal fins lapped over her back, and with tremulous motions the spawn was emitted and fertilized. The males were quite black on top of head and shoulders, with bright yellow throat and sides.

19. **Fundulus ocellaris** Jordan & Gilbert. Salt-water Minnow.

Card's Sound. This and the following cyprinodonts are very abundant in the brackish water of all bays and bayous, in the small streams emptying into them, and also in adjacent fresh-water ponds.

20. **Fundulus heteroclitus** (Linnæus). Salt-water Minnow.

Barnes' Sound; Gordon's Pass; Myakka River; Stump Pass.

21. **Cyprinodon variegatus** Lacépède. Toothed Minnow.

Barnes' Sound; Big Gasparilla; Myakka River; brackish pond near Stump Pass; Long Boat Key.

22. **Cyprinodon carpio** Günther. Toothed Minnow.

Card's Sound; Barnes' Sound; Key West; Marco; Gordon's Pass; San Carlos Pass; Big Gasparilla; Long Boat Key; Sarasota Bay. This is *Cyprinodon mydrus* Goode & Bean.

23. **Zygonectes chrysotus** (Günther). Top Minnow.

Myakka River and fresh pond near the river. Female with pearl-colored dots scattered over the sides; male nearly plain, with narrow dark crossbars posteriorly.

24. **Zygonectes henshalli** Jordan. Top Minnow.

Gordon's Pass; Myakka River. Numerous specimens, apparently the young of this species. Body with about ten dark crossbars; caudal with crossbars of dark dots.

25. **Gambusia patruelis** (Baird & Girard). Mud Minnow.

Myakka River and fresh pond near the river.

26. **Mollienesia latipinna** Le Sueur. Big-finned Minnow.

Card's Sound; Barnes' Sound; Gordon's Pass; Stump Pass; Lemon Bay.

OPHISURIDÆ.

27. **Mystriophis intertinctus** (Richardson).

Lemon Bay; one young specimen. *Mystriophis punctifer* (Kaup), *M. mordax* (Poey), and *M. schneideri* (Steindachner) are probably all identical with the present species.

SCOMBERESOCIDÆ.

28. **Tylosurus notatus** (Poey). Billfish.

Card's Sound; Black Sound; west coast of Florida. This and the young of the next species are abundant in the bays and harbors of the west coast, swimming in large schools, and are preyed upon by all surface-feeding fishes, as the Spanish mackerel, kingfish, salt-water trout, etc. The steward of the *Grampus* cooked a quantity at Boca Grande, on Charlotte Harbor, which were greatly relished by the crew. When fried they remind one somewhat of smelts.

29. **Tylosurus marinus** (Bloch & Schneider). Billfish.

Card's Sound; Lemon Bay; west coast of Florida.

30. **Hemirhamphus roberti** Cuv. & Val. Needlefish.

Cape Sable Creek; west coast of Florida; also abundant in schools in similar situations as the billfishes; when fried are quite palatable.

SYNGNATHIDÆ.

31. **Siphostoma affine** (Günther). Pipe-fish.

Card's Sound; Barnes' Sound; Key West; Marco; Big Gasparilla; Lemon Bay; Long Boat Key; Garden Key. The young of this, and the other pipe-fishes which follow, are common in the eelgrass and weeds of all shallow bays and coves.

32. **Siphostoma louisianæ** (Günther). Pipe-fish.

Egmont Key.

33. **Siphostoma floridæ** Jordan & Gilbert. Pipe-fish.

Gordon's Pass; Big Gasparilla.

HIPPOCAMPIDÆ.

34. **Hippocampus zosteræ** Jordan & Gilbert. Sea Horse.

Three specimens about $1\frac{1}{2}$ inches long. That this species is adult at this small size is shown by the fact that the pouch of a male specimen is full of young more than a third of an inch long, the tails of two of them projecting conspicuously from his pouch.

MUGILIDÆ.

35. **Mugil curema** Cuv. & Val. Silver Mullet.

Barnes' Sound; Cape Romano; Marco; Gordon's Pass; Big Estero Pass. The silver mullet does not grow so large as the next species, nor is it so abundant; neither is it so desirable a food-fish.

36. **Mugil cephalus** Linnæus. Striped Mullet.

Cape Sable Creek; west coast of Florida. This is the commercial "mullet." It is taken in immense numbers at the fishing ranches of the west coast, where it is salted and shipped to Key West and Havana. It is at its best in October and November,

when full of roe, being then quite fat and a delicious fish broiled. It spawns in October and November in brackish water. Its usual weight is a pound or two, as taken at the fishing ranches. The most abundant fish on the Florida coast.

The Pickens Ranch at Gasparilla was the only one in operation during my trip. They were taking mullet and sheepshead, with red-fish and salt-water trout, and salting them for the Cuban market during the Lenten season.

37. Mugil trichodon Poey. Fan-tail Mullet.

Key West. Three young specimens.

38. Querimana gyrans Jordan & Gilbert. Little Mullet.

Marco; Gordon's Pass; Myakka River. This pigmy mullet is abundant in most of the inlets and bays of the southwest coast.

ATHERINIDÆ.

39. Atherina stipes Müller & Troschel. Sardine.

Card's Sound; Barnes' Sound. Very common in the shallow waters of the sounds and of Florida Bay at the southern extremity of the peninsula. It is a good bait for any of the large surface-feeding fishes.

40. Labidesthes sicculus Cope. Duck-bill Silversides.

Myakka River. This is the southernmost record of this widely distributed species.

41. Menidia vagrans Goode & Bean. Silversides.

Barnes' Sound; Cape Sable Creek; Cape Romano; Marco. This and the next species of silversides are abundant in the shallow portions of all bays visited.

42. Menidia peninsulæ Goode & Bean. Silversides.

Barnes' Sound; Marco; San Carlos Pass; Big Gasparilla; Myakka River; Big Sarasota Bay; Long Boat Key.

SPHYRÆNIDÆ.

43. Sphyræna picuda (Bloch & Schneider). Barracuda.

Card's Sound; Key West; west coast of Florida. The shallow waters between the Florida Keys and the mainland seem to be the favorite feeding or breeding grounds of this formidable fish. I saw numerous specimens fully 6 to 7 feet long, and several of this size were speared by my pilot, a native of Key West, who was very expert in the use of the two-pronged spear or "grains." It is a favorite food-fish with Key West people, and is usually taken with the "grains."

ECHENEIDIDÆ.

44. Echeneis naucrates Linnæus. Shark Sucker.

Lemon Bay; Sarasota Bay; Garden Key. From one to half a dozen specimens of this fish, from 6 to 12 inches in length, are usually attached to sharks, and permit themselves to be taken from the water with their host when captured on the grains or with a shark-line.

While at anchor in Sarasota Bay I noticed several large ones attached to the rudder and stern-post of my boat. With a baited hook I soon caught them all, as they are very voracious, and will take anything in the way of fish or flesh bait. They were fully 2 feet long. When affixed by the "sucking disk" (a modification of the dorsal

fin) to a shark or other object it is difficult to detach one by a direct pull, but by a quick, sliding, forward motion it is easily removed. I have seen them 3 to 4 feet in length. They seem to attach themselves to sharks to secure fragments of food which are frequently ejected by their overfed hosts.

SCOMBRIDÆ.

45. Scomberomorus maculatus (Mitchill). Spanish Mackerel.

West coast of Florida. Owing to the unusual coolness of the water this fine species did not put in an appearance in any considerable numbers until the latter part of March. In April the schools were abundant in Tampa Bay and were taken by anglers from the piers at Port Tampa, in company with the salt-water trout (*C. maculatus*).

CARANGIDÆ.

46. Oligoplites saurus (Bloch & Schneider). Leather Jacket.

West coast of Florida. Not uncommon about the inlets.

47. Trachurus trachurus Linnæus. Skipjack.

Gulf of Mexico; one specimen. Scutes 36–38, as usual in European specimens.

48. Caranx chrysus (Mitchill). Runner.

West coast of Florida. This and the next species were abundant in all channels during the winter and spring, advancing and retreating with the tide. They bite readily at a bait or troll, or the artificial fly, and are caught in great numbers by anglers from the banks of inlets or passes, or by trolling in the channels. They are fair food-fishes and give considerable sport to the angler.

49. Caranx hippos (Linnæus). Jack. Cavalla.

West coast of Florida.

50. Selene vomer (Linnæus). Moonfish.

West coast of Florida. Not uncommon at the mouths of deep inlets.

51. Trachinotus carolinus (Linnæus). Pompano.

Egmont Key. Owing to the cool water this prince of food-fishes was remarkably scarce during my voyage. At Pickens's Ranch, on Gasparilla, only about twenty-five had been taken at the time of my visit, though the fishermen hauled whenever the tide served on the outside beaches. It was full of nearly ripe spawn in April.

52. Trachinotus falcatus (Linnæus). Cobbler; Pompano. (*Trachinotus ovatus* (L.).)

Key West; one young specimen.

NOMEIDÆ.

53. Nomeus gronovii (Gmelin).

Gulf of Mexico. Numerous specimens were taken from floating sea-weed and jelly-fishes, but mostly from the "Portuguese man-of-war" (*Physalia*).

STROMATEIDÆ.

54. Stromateus triacanthus Peck. Dollar fish.

Lemon Bay; Big Sarasota Bay. Young specimens. As yet, no adult of this species seems to have been taken in the Gulf of Mexico. The specimens collected were all taken from beneath the disks of large floating jelly-fishes.

CENTRARCHIDÆ.

55. **Chænobryttus gulosus** Cuv. & Val. Warmouth Bream.

Myakka River and fresh pond near the river. This and the other sunfishes obtained are common species of the southern lowlands.

56. **Enneacanthus obesus** (Baird). Little Bream.

Myakka River. The most southern locality recorded for this species.

57. **Lepomis holbrooki** Cuv. & Val. Yellow Bream.

Myakka River. The most southern locality yet recorded for this sunfish.

58. **Lepomis punctatus** Cuv. & Val. Spotted Bream.

Myakka River. Abundant in all fresh waters in Florida. I have taken it much farther south on the east coast, in waters emptying into Biscayne Bay.

59. **Lepomis pallidus** Mitchill. Blue Bream.

Western Florida. Specimens from a fresh-water pond on Point Pinellas were the most brilliantly colored sunfishes I have ever seen, the tints being yellow, green, rosy, and purple, the latter predominating below and of a very intense hue.

SERRANIDÆ.

60. **Serranus subligarius** (Cope).

Big Gasparilla; Lemon Bay. Small specimens not uncommon in the bays.

CENTROPOMIDÆ.

61. **Centropomus undecimalis** (Bloch). Ravallia; Snook.

West coast of Florida. Abundant in all bays and brackish waters and running up the larger fresh streams. A voracious, gamy fish with pikelike habits. My pilot grained some in Card's Sound ranging up to 25 or 30 pounds in weight. It is a fair food-fish, but tastes somewhat soapy or slimy unless skinned. The fin formula of several was D. VI, 10; A. II, 6.

SPARIDÆ.

62. **Lutjanus synagris** (Linnæus). Lane Snapper.

Barnes' Sound; Key West; Lemon Bay. This pretty and strongly marked species was very abundant along the Florida Keys, and is a favorite pan-fish at Key West. The young were common along the west coast.

63. **Lutjanus analis** (Cuv. & Val.). Mutton-fish.

West coast of Florida. A common species in the channels about the Keys, and a fairly good food-fish, growing to a foot or two in length. Not seen along the mainland.

64. **Lutjanus griseus** (Linnæus). Mangrove Snapper.

Key West; Myakka River. Abundant about the mangroves in all bays and inlets, and often in brackish water. It is a good game fish, taking both bait and artificial fly, but being very shy it must be fished for cautiously. It is a good food-fish, usually weighing a pound or two, occasionally five or six.

65. **Lutjanus aya** (Bloch). Red Snapper.

Key West; Snapper Banks. A large number of this well-known species was taken with hand-lines on the "banks" north of Dry Tortugas by the *Grampus*, weighing from 5 to 20 pounds each.

66. **Lutjanus caxis** (Bloch & Schneider). Schoolmaster Snapper.

Card's Sound; Key West; Big Gasparilla; west coast of Florida. Especially common about the Keys, and one of the numerous pan-fishes taken to the Key West market.

67. **Hæmulon plumieri** (Lacépède). Common Grunt; Sow Grunt.

Key West. The most common and most esteemed of the pan-fishes sold in the Key West market, and one of the most beautiful.

68. **Hæmulon sciurus** (Shaw). Yellow Grunt; Boar Grunt.

Garden Key; Key West. The handsomest of the "grunts." It is abundant in the channels about the Keys, where it is taken by the fishermen with sea-crawfish for bait. It is popularly supposed to be the male of the preceding species. The young are found in grassy coves about Key West.

69. **Hæmulon parra** (Desmarest). Black Grunt.

Card's Sound; Key West; Marco; Lemon Bay. The young of this species were more generally distributed along the west coast than those of the other grunts.

70. **Lagodon rhomboides** (Linnæus). Bream; Sailor's Choice.

Key West; Marco; Gordon's Pass; Big Gasparilla; Myakka River; San Carlos Pass. This pretty and well-known species is abundant all around the coasts of Florida, and is a good pan-fish, though of small size. The very young were abundant in brackish water.

71. **Archosargus probatocephalus** (Walbaum). Sheepshead.

Key West; west coast of Florida. One of the most abundant fishes on the west coast, particularly about mangrove roots covered with coon oysters, oyster beds, and barnacle-covered piles of wharves, etc. It is very rare about the Keys. I saw but one specimen at Key West, which was given to me by a fisherman, with the name of "sheepshead porgy." Large numbers are taken at the fishing ranches and salted with the mullet. Spawns in Florida in March and April.

MULLIDÆ.

72. **Upeneus maculatus** (Bloch). Goat-fish.

Key West; Garden Key. Young specimens not rare about the Keys.

SCIÆNIDÆ.

73. **Bairdiella chrysura** (Lacépède). Yellow-tail.

Myakka River. A pan-fish occurring commonly at Key West, and the young not scarce in the bays and bayous of the west coast.

74. **Leiostomus xanthurus** (Lacépède). Spot.

Marco; Gordon's Pass; Big Gasparilla; Myakka River; San Carlos Pass; Egmont Key; Long Boat Key. The young are very abundant in all bays of the southwest and west coasts.

75. **Menticirrus americanus** (Linnæus). Whiting.

Marco; Charlotte Harbor; Garden Key. The whiting is rather a rare fish on the west coast. I saw but one adult specimen, which I took at Cape Haze, at the head of Charlotte Harbor. The young were not uncommon.

76. **Menticirrus littoralis** (Holbrook). Whiting.

Egmont Key. Still more scarce than the preceding species. Only a few young specimens seen.

77. Micropogon undulatus (Linnæus). Croaker.

Marco; Gordon's Pass. The young are especially abundant in the shallow coves of the bays on the west coast, some being but an inch or two in length.

78. Sciæna ocellata (Linnæus). Redfish.

Gordon's Pass; Myakka River; west coast of Florida. Very abundant in the bays and brackish water, and running up fresh-water streams. Not seen along the Keys. No very young were observed, but we took adults up to 40 pounds in weight. The characteristic spot on the tail was sometimes broken up into two or three, and one taken by the seine of the *Fish Hawk* near Punta Gorda had as many as twelve small spots.

GERRIDÆ.

79. Gerres harengulus (Goode & Bean). "Shad."

Barnes' Sound; Key West; Lemon Bay; Garden Key. This and the next species of so-called "shad" are very abundant all along the west coast. Not esteemed as food-fishes.

80. Gerres gula (Cuv. & Val.). "Shad."

Card's Sound; Barnes' Sound; Key West; Cape Sable Creek; Cape Romano; Marco; Gordon's Pass; San Carlos Pass; Big Gasparilla; Long Boat Key; Egmont Key; Garden Key.

81. Gerres cinereus (Walbaum). Broad "Shad." Irish Pompano.

Card's Sound; Cape Romano; Gordon's Pass; Myakka River. This is a larger species than the preceding and is sometimes sold in the Key West market. I have heard it called "Irish Pompano."

EPHIPPIDÆ.

82. Chætodipterus faber (Linnæus). Angel-fish.

West coast of Florida. One of the best food-fishes, but not abundant along shore.

POMACENTRIDÆ.

83. Pomacentrus leucostictus (Müller & Troschel). Cock-eyed Pilot.

Garden Key, Dry Tortugas. This beautiful little fish is not uncommon about the coral reefs.

LABRIDÆ.

84. Lachnolaimus maximus (Walbaum). Hog-fish.

Key West. A handsome and much esteemed food-fish at Key West, growing to several pounds in weight, and rather common.

85. Halichœres radiatus (Linnæus). Pudding-wife.

Key West. This gay-colored fish with rainbow hues is a common food-fish at Key West. It reaches several pounds in weight.

86. Halichœres bivittatus (Bloch). Slippery Dick.

Key West; Big Gasparilla; Lemon Bay; Garden Key. Almost as gaily colored as the preceding species, but much smaller and not esteemed as a food-fish. The young are not uncommon in quiet, grassy coves about the Keys.

87. Doratonotus megalepis Günther.

Garden Key, Dry Tortugas. Two fine specimens of this rare and beautiful fish were taken.

88. **Sparisoma distinctum** (Poey). Parrot-fish.
Garden Key, Dry Tortugas. Small specimens, apparently of this species.

89. **Sparisoma flavescens** (Bloch & Schneider). Parrot-fish.
Key West. Young specimens of this and the next species are abundant in the grassy coves, especially between the Marine Hospital and Fort Taylor, at Key West. A small and unimportant species as a food-fish.

90. **Sparisoma hoplomystax** (Cope). Parrot-fish.
Key West. This is *Sparisoma cyanolene* Jordan & Swain.

SCORPÆNIDÆ.

91. **Scorpæna grandicornis** (Cuv. & Val.).
Key West. The young were found in the same situations as the preceding species.

TRIGLIDÆ.

92. **Prionotus tribulus** (Cuv. & Val.). Sea Robin.
Cape Romano; Gordon's Pass; Big Gasparilla; San Carlos Pass. The young of this and the next species are common in the eelgrass of the bays and bayous.

93. **Prionotus scitulus** Jordan & Gilbert. Sea Robin.
Cape Romano; Big Gasparilla.

GOBIIDÆ.

94. **Microgobius thalassinus** Jordan & Gilbert.
Marco Inlet. This and the following little "gobies" are not uncommon among the grass and weeds of sheltered situations in the bays.

95. **Microgobius gulosus** (Girard). Goby.
Card's Sound; Marco; Gordon's Pass; Big Gasparilla; Myakka River; Lemon Bay; Long Boat Key.

96. **Gobius soporator** Cuv. & Val. Rock-fish.
Marco; Myakka River.

97. **Gobius stigmaturus** Goode & Bean. Goby.
Card's Sound.

98. **Gobius smaragdus** Cuv. & Val. Goby.
Marco; Gordon's Pass. Numerous specimens of this species, previously known on the Florida coast from only a single specimen taken at St. Augustine.

99. **Gobiosoma molestum** Girard. Goby.
Card's Sound; Marco; Gordon's Pass; Big Gasparilla; Myakka River; Lemon Bay.

BLENNIIDÆ.

100. **Auchenopterus marmoratus** (Steindachner). Blenny.
Card's Sound. This species and the next had not previously been taken north of Key West.

101. **Auchenopterus fasciatus** (Steindachner). Blenny.
Card's Sound.

BATRACHIDÆ.

102. Batrachus tau Linnæus. Toad-fish. Oyster-fish.

Big Gasparilla; Lemon Bay. This and the next *bizarre* species are common about oyster beds. They are harmless, but by the fishermen are thought to be poisonous.

103. Batrachus pardus Goode & Bean. Toad-fish.

West coast of Florida.

LEPTOSCOPIDÆ.

104. Dactyloscopus tridigitatus Gill.

Key West. Not common.

PLEURONECTIDÆ.

105. Platophrys ocellatus Agassiz.

Key West; Garden Key. The young of this and the following "flat fishes" are common in quiet, grassy situations, the larger ones being found in deeper water.

106. Citharichthys macrops Dresel.

Big Gasparilla; Egmont Key.

107. Paralichthys albigutta Jordan & Gilbert.

Marco; Gordon's Pass; Big Gasparilla; Lemon Bay.

108. Paralichthys squamilentus Jordan & Gilbert.

Egmont Key.

109. Etropus crossotus Jordan & Gilbert.

Gordon's Pass; San Carlos Pass.

110. Achirus lineatus (Linnæus).

Barnes' Sound; Gordon's Pass; Big Gasparilla.

111. Achirus fasciatus Lacépède.

Myakka River.

112. Symphurus plagiusa (Linnæus). Sole.

Marco; Gordon's Pass; Big Gasparilla; Lemon Bay; Long Boat Key.

BALISTIDÆ.

113. Balistes carolinensis Gmelin. Turbot.

West Coast of Florida. Common. Taken to Key West as a food-fish.

114. Monacanthus ciliatus (Mitchill). Leather-fish.

Big Gasparilla; Garden Key. This and the following "leather-fishes" are not uncommon, but are not used for food.

115. Monacanthus hispidus (Linnæus). Leather-fish.

Key West; Big Gasparilla.

OSTRACIIDÆ.

116. Ostracion trigonum (Linnæus). Shell-fish.

West coast of Florida. This and other "cow-fishes" or "trunk-fishes" are roasted "in the shell," and are very fair food-fishes.

DIODONTIDÆ.

117. **Chilomycterus schœpfi** Walbaum. Porcupine-fish.

Egmont Key. This and the other "puffers" or "swell-fish" are common, but never eaten.

TETRODONTIDÆ.

118. **Spheroides spengleri** (Bloch). Swell-fish.

Key West; Big Gasparilla.

119. **Spheroides maculatus** (Bloch & Schneider).

Big Estero Pass. This northern species has not hitherto been recorded from any point south of Beaufort, North Carolina.

ANTENNARIIDÆ.

120. **Antennarius ocellatus** (Bloch). Toad-fish.

Lemon Bay. This queer form is rather common about mud-flats.

121. **Pterophryne histrio** (Linnæus). Mouse-fish.

Gulf Stream, off Savannah. Taken from floating sea-weed.

MALTHIDÆ.

122. **Malthe radiata** (Mitchill). Bat-fish.

West coast of Florida. Rather common in sheltered bays with muddy or sandy bottom.

SUPPLEMENTAL LIST.

The following species were collected or observed during the investigation, but specimens were not retained because of the limited space available for the preservation of our collections.

GALEORHINIDÆ.

123. **Galeocerdo maculatus** (Ranzani). Leopard Shark.

Indian Key. A large one passed within a few feet of my boat off Indian Key. Recognized by its very long caudal fin and spotted coloration. Called by my pilot "leopard-shark."

124. **Carcharhinus platyodon** (Poey). Man-eater.

Florida Keys, west coast of Florida. Met with frequently at most of the inlets and passes, and taken on shark line. Teeth strongly serrate, upper and lower.

125. **Carcharhinus lamia** (Risso). Cub Shark.

Key Largo; Dry Tortugas. We caught one at Key Largo, 9 feet in length, and saw several in the harbor of Garden Key, back of Fort Jefferson, which answered the description of Dr. Jordan in Proc. U. S. National Museum, 1884, p. 104.

126. **Carcharhinus brevirostris** (Poey). Blue Shark.

Cape Sable Creek; Marco. Shot 2 specimens at the entrance to Cape Sable Creek, and caught one on a shark line at Marco Inlet, which I took to be this species. Lower teeth, entire and narrow; upper teeth, serrate.

127. Carcharhinus terræ-novæ (Richardson). White Shark.

Cape Sable Creek; Marco; Gasparillas. A common shark about the Keys and southwest coast. Captured several specimens on shark line.

SPHYRNIDÆ.

128. Sphyrna tiburo (Linnæus). Bonnet-head Shark.

Charlotte Harbor. Captured a small one with the seine of the *Grampus* at Boca Grande, Charlotte Harbor.

129. Sphyrna zygæna (Linnæus). Hammer-head Shark.

Card's Sound; Florida Bay. Saw several on the southern coast between the Keys and mainland. Caught a small one with the grains at Cottonwood Key.

TRYGONIDÆ.

130. Trygon sayi (Le Sueur). Sting Ray; Stingaree.

West coast of Florida. Abundant in all shallow bays on the west coast. Caught a number in Charlotte Harbor and Tampa Bay.

MYLIOBATIDÆ.

131. Stoasodon narinari (Euphrasen). Spotted Ray.

Captured one specimen in Lemon Bay which I took to be this species. Disk much broader than long; tail four times the length of disk; color olivaceous, with small grayish white spots.

132. Rhinoptera quadriloba (Le Sueur). Cow-nosed Ray.

A young ray was grained in Barnes' Sound, presumably of this species. Disk much broader than long; snout apparently four-lobed; tail slender, as long as disk, with serrated spine. A larger one, apparently of this species, was also seen in shallow water near Cape Sable.

CEPHALOPTERIDÆ.

133. Manta birostris (Walbaum). Devil-fish.

Bocilla Pass; Punta Rassa; Tampa Bay. Saw a school of young devil-fish in the Gulf near Bocilla Pass. They passed within a few feet of my boat, so near that this well-marked species could not be mistaken for anything else. They were about 2 feet across the pectorals. Also saw a school of large ones, off Punta Rassa, that would measure from 10 to 20 feet across disk. Captured a small one in the seine at Tampa Bay.

LEPISOSTEIDÆ.

134. Lepisosteus osseus (Linnæus). Garfish.

Estero Bay. Took a specimen 3 feet in length on the east side of Estero Bay, near the mouth of a brackish stream.

AMIIDÆ.

135. Amia calva Linnæus. Mudfish.

Tampa. Saw a number in Hillsborough River at Tampa, and several that had been caught by a negro while fishing.

CYPRINIDÆ.

136. **Notemigonus chrysoleucus** (Mitchill). Golden Shiner.

Myakka River; Tampa. This species is common in the fresh and brackish streams emptying into Myakka and Hillsborough Rivers.

ALBULIDÆ.

137. **Albula vulpes** (Linnæus). Bonefish.

Key West; Pavilion Key; San Carlos Pass. Took a number of specimens with bait and artificial fly, and captured a few in the seines—all adult; young not seen.

ELOPIDÆ.

138. **Megalops atlanticus** (Cuv. and Val.). Tarpon.

Card's Sound. Grained several from 10 to 30 pounds in weight in Card's Sound, but did not meet with it again on the west coast owing to the water being unusually cold. When I arrived at Punta Rassa on March 3 I learned that the first tarpon of the season had been taken the day before, although a score of anglers had been fishing for them daily for several weeks. I have never seen the young on the Florida coasts, the smallest observed being from 8 to 10 pounds in weight.

CLUPEIDÆ.

139. **Clupea pensacolæ** (Goode and Bean). Striped Pilchard.

Florida Keys, west coast of Florida. A very common species at deep-water inlets and about the Keys.

MURÆNIDÆ.

140. **Sidera funebris** (Ranzani). Green Moray.

Dry Tortugas; Key West; Marco. Captured a large one at Loggerhead Key, Dry Tortugas. Saw several at Key West, and took one in the seine at Marco, too large to preserve.

141. **Sidera moringa** (Cuvier). Moray.

Key Largo; Key West. Took two large specimens at Key Largo, and saw one at Key West.

BELONIDÆ.

142. **Tylosurus crassus** (Poey). Hound.

Florida Keys. Took several along the Keys from 2 to 4 feet long. Frequently saw them skipping along the surface and sometimes making long horizontal leaps above the water.

143. **Hemirhamphus unifasciatus** Ranzani. Needle-fish.

Florida Keys. Took a number of specimens of this and the next species along the Keys and at Dry Tortugas, but none small enough to go into my collecting jars.

144. **Hemirhamphus balao** Le Sueur. Needle-fish.

Florida Keys.

145. **Exocœtus exiliens** Gmelin. Flying-fish.

Gulf of Mexico; Atlantic Ocean. Saw numerous specimens; one or two were taken aboard, which I identified as belonging to this species.

HIPPOCAMPIDÆ.

146. **Hippocampus hudsonius** De Kay. Sea Horse.

Egmont Key. Saw several large examples of this species in the collection at the light-house on Egmont Key. The specimens were dry, but speckled coloration and whitish streaks about the eye were plainly discernible. D. 19, covering 3½ rings; 11 body rings.

SCOMBRIDÆ.

147. **Scomberomorus regalis** (Bloch). Kingfish.

Key West; Florida Keys. Captured a number of this and the next species on trolling lines while sailing along the Keys. They bite readily at a bait of pork rind, a spinner, or even a bit of white rag. Small herring-like fishes, as pilchard, anchovy, etc., also make good baits. They are excellent food-fishes.

148. **Scomberomorus cavalla** (Cuvier). Kingfish.

Key West; Florida Keys.

149. **Sarda sarda** (Bloch). Bonito.

Florida Keys; West Coast of Florida. Also caught frequently while trolling. A handsome fish of good size, but dark-meated and not very desirable as a food-fish.

CARANGIDÆ.

150. **Decapterus punctatus** (Agassiz). Scad.

Charlotte Harbor; Dry Tortugas. Took a specimen at Boca Grande, Charlotte Harbor, and one at Garden Key, Dry Tortugas. Scutes 38.

151. **Trachinotus rhodopus** Gill. Permit.

Loggerhead Key, Dry Tortugas. Took one weighing fully 25 pounds at Loggerhead Key. Color, light olivaceous on back, silvery on sides and below; dorsal and caudal fins dark.

152. **Seriola lalandi** Cuv. & Val. Amber Jack.

Florida Keys. Took several on trolling lines weighing from 20 to 35 pounds.

POMATOMIDÆ.

153. **Pomatomus saltatrix** (Linnæus). Bluefish.

Lemon Bay. Saw but one specimen, a young example 3 inches in length, taken in the seine at Lemon Bay.

CENTRARCHIDÆ.

154. **Micropterus salmoides** (Lacépède). Large-mouth Black Bass; Trout.

Myakka River; Hillsborough River. Took numerous specimens in Myakka and Hillsborough Rivers and tributaries, in fresh and brackish waters.

SERRANIDÆ.

155. **Serranus atrarius** (Linnæus). Blackfish.

Tampa Bay. Took several large ones on hook and line in Tampa Bay.

156. **Serranus formosus** (Linnæus).

Key West; Gordon's Pass. Saw several examples at Key West market, and took one on hook and line at Gordon's Pass. A handsome fish and very fair for the table,

157. **Mycteroperca falcata phenax** Jordan & Swain. Scamp.

Key West; Ironwood Key; Key Largo. Took several large specimens on hook and line along the Keys, weighing 4 to 10 pounds. Common in Key West market.

158. **Mycteroperca microlepis** (Goode & Bean). Gag.

Key West; west coast. Taken on trolling line along the Keys and west coast. Common in Key West market, where I saw many specimens.

159. **Mycteroperca bonaci** (Poey). Black Grouper.

Key West; west coast. Saw several large ones at Key West; took several on hook and line on west coast, all large ones.

160. **Epinephelus nigritus** (Holbrook). Jew-fish.

Marco; Gordon's Pass; Charlotte Harbor. At Marco and Caximbas Passes, just north of Cape Romano, and at Gordon Pass, I took on fishing line several weighing from 10 to 40 pounds, and at the latter place saw one taken weighing fully 60 pounds. On former occasions I took one at Jupiter Inlet, on the southeast coast, that weighed on the light-house steelyard 340 pounds, and one on the southwest coast at Little Gasparilla Inlet weighing fully 300 pounds. These two fishes were respectively 7 and 6¾ feet long, and of about the same girth at the pectoral fin. Some large examples of jew-fishes have been heretofore confounded with the Guasa or Warsaw (*Promicrops itaiara*), but I do not remember to have ever seen the latter fish at all, or one answering to its description, on the coasts of Florida. All specimens of the jew-fish I have seen were of a uniform dusky coloration, both in small and large examples, with quite small scales (not less than 120 in the lateral line) and those of the lateral line not conspicuously furrowed. Teeth in broad bands, but without canines.

161. **Epinephelus morio** (Cuv. & Val.). Red Grouper.

Key West; Florida Keys; west coast. A common food-fish at Key West, seen in the market daily, and held in good favor. I have taken it along the Keys and on the southwest coast at various points ranging up to 10 or 12 pounds.

162. **Epinephelus striatus** (Bloch). Nassau Grouper.

Key West; Florida Keys. Another common food-fish brought to Key West daily, by the small fishing smacks, and caught in the channels between the Keys on hook and line, and with sea-crawfish bait. It sells readily with the other groupers, and is usually of several pounds weight.

163. **Epinephelus drummond-hayi** Goode & Bean. Speckled Hind.

Key West; Florida Keys. I saw several specimens of this handsome little grouper at Key West and the Dry Tortugas, though it does not seem to be as common as others of the genus. Color, a reddish or chocolate brown, with numerous white, stellate spots, covering the entire body. Length, 8 to 15 inches.

164. **Epinephelus apua** (Bloch). Red Hind.

Garden Key; Dry Tortugas. I took one specimen, apparently of this species, at Garden Key, called by my Key West pilot "Red Hind," and which answered to the description in most points, especially in coloration.

165. **Epinephelus ascensionis** (Osbeck). Rock Hind.

Key West. This species is brought to Key West almost daily, and is readily sold by the fishermen, being much esteemed as a food-fish, though of small size—about a foot in length.

166. **Enneacentrus guttatus** (Linnæus). Coney.

Key West; Dry Tortugas. A rather common food-fish at Key West, about a foot in length, and can be seen daily on the arrival of the small smacks. These are of the variety called *coronatus*, though I saw one at Key West, and several at Garden Key, called "Coney," which were apparently of the variety named *guttatus*, the coloration being quite red or scarlet instead of olivaceous or brown.

167. **Enneacentrus fulvus** (Linnæus). Nigger-fish.

Key West. The three varieties of the "nigger-fish," yellow (*fulvus*), red (*ruber*), and brown (*punctatus*), are occasionally seen in the Key West market. They are known, locally and collectively, as "nigger-fish," and sell readily with other pan-fishes, being of small size—less than a foot in length usually.

SPARIDÆ.

168. **Ocyurus chrysurus** (Bloch). Yellow-tail.

Key West; Florida Keys. Very abundant along the Keys, and one of the commonest pan-fishes in the Key West market.

169. **Orthopristis chrysopterus** (Linnæus). Sailor's Choice.

Key West; west coast. A very good pan-fish, common at Key West and at the deep inlets of the west coast, where I took it at several points.

170. **Anisotremus virginicus** (Linnæus). Pork-fish.

Key West. A handsome and greatly esteemed fish in Key West, reaching several pounds in weight, and quite common in the channels between the Keys.

171. **Hæmulon rimator** Jordan & Swain. Tom Tate.

Key West; Florida Keys. I saw this small pan-fish at Key West and along the Keys to the northeast. It is not very common.

172. **Calamus bajonado** (Bloch & Schneider). Jolthead Porgy.

Key West. Saw several specimens at Key West, where it is ranked as a good food-fish and occasionally weighs several pounds.

173. **Calamus proridens** Jordan & Gilbert. Little-head Porgy.

Key West; Florida Keys. Took a number of this species along the Keys, also the two following species.

174. **Calamus calamus** (Cuv. & Val.). Porgy.

Key West; Florida Keys.

175. **Calamus arctifrons** Goode & Bean. Grass Porgy.

Key West; Florida Keys. This and the foregoing "porgies" are common about the Keys in grassy situations. They are very fair pan-fishes.

SCIÆNIDÆ.

176. **Pogonias chromis** (Linnæus). Drum.

West coast. One of the commonest species of the west coast about the inlets and bays, associating with the sheepshead wherever oysters abound. Its "drumming" can be heard all through the night in the quiet coves and bays. I have taken it up to 30 pounds. A fair food-fish.

177. Cynoscion maculatum (Mitchill). Spotted Trout.

West coast. Abundant in all bays and sounds of the west coast, and often running up the fresh-water streams. It is a fine food-fish, and being a surface feeder is a great favorite with anglers, taking both natural bait and the artificial fly. I have taken it weighing upward of 10 pounds. Spawns in March and April in Florida.

OSTRACIIDÆ.

178. Ostracion tricorne Linnæus. Cow-fish.

West coast. Abundant in grassy coves in all bays of the west coast. Like the other "trunk-fishes," it is roasted "in the shell," by the Key-Westers.

TETRODONTIDÆ.

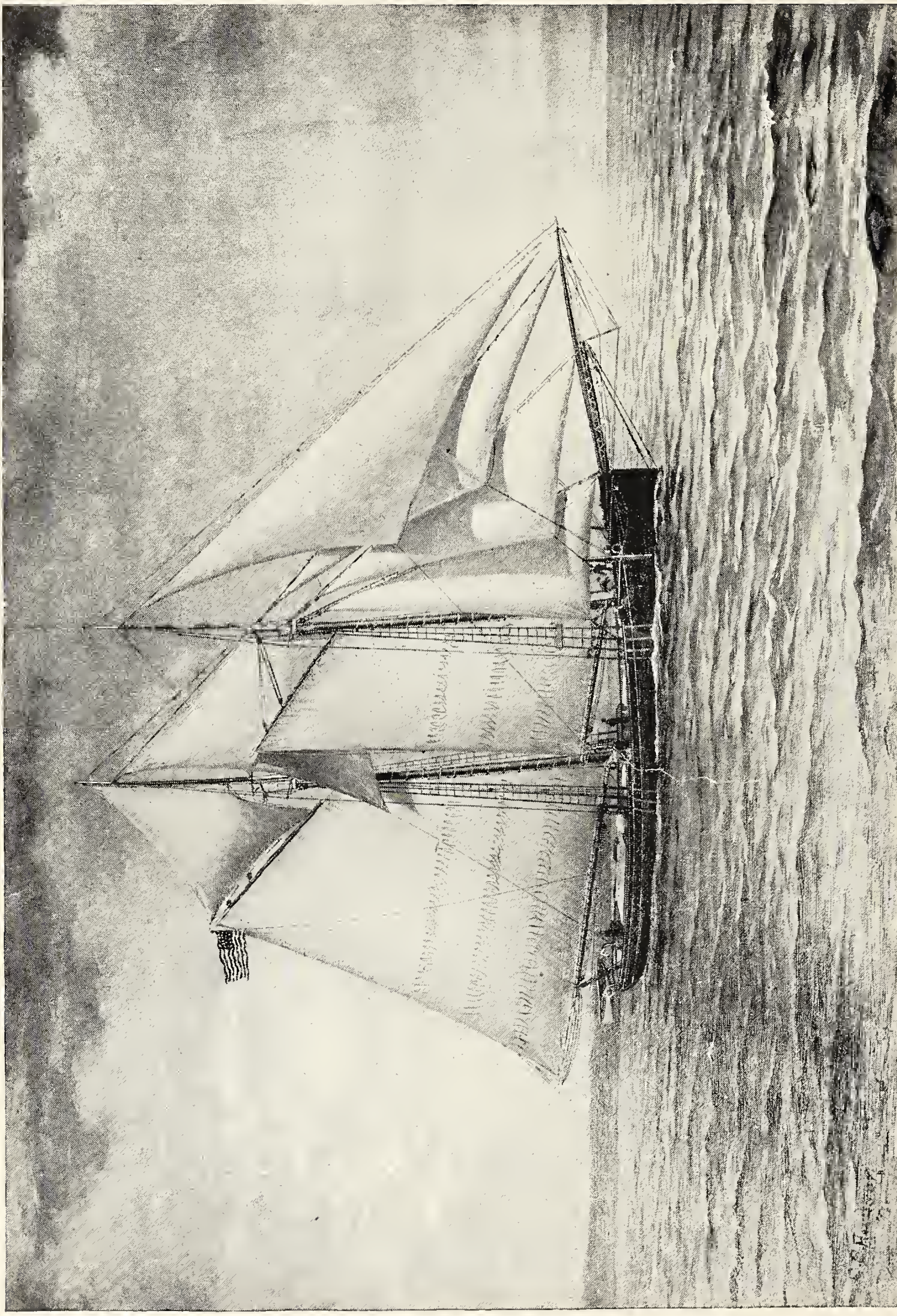
179. Lagocephalus lævigatus (Linnæus). Puffer.

Florida Keys; west coast. Common about the Keys and inlets.

DIODONTIDÆ.

180. Diodon hystrix Linnæus. Porcupine-fish.

Florida Keys. Saw several large specimens at Key West, inflated and dried, and kept as curiosities, that were taken about the Keys. I took one small specimen at Dry Tortugas.



THE GRAMPUS UNDER SAIL.

21.—REPORT UPON A PHYSICAL INVESTIGATION OF THE WATERS OFF THE SOUTHERN COAST OF NEW ENGLAND, MADE DURING THE SUMMER OF 1889 BY THE U. S. FISH COMMISSION SCHOONER GRAMPUS.

BY WILLIAM LIBBEY, JR., SC. D.

Professor of Physical Geography, College of New Jersey, Princeton.

[Plates CXXIV–CLVIII and one text figure.]

PURPOSE AND PLAN OF THE INVESTIGATION.

During a part of the summer of 1889 the Fish Commission schooner *Grampus* was assigned to the investigation (under the direction of the writer) of certain problems relating to the waters lying off the coast of the New England and Middle States. The object of the expedition was to study the temperature relations between the cold wall of the Labrador current and the warm waters of the Gulf Stream, with the idea of establishing some connection between the changes in temperature in the waters and the migrations of the fish which inhabit them. That such a connection does exist has been shown by the researches of the Commissioner of Fisheries, Mr. M. McDonald, upon the shad, and of Prof. G. Brown Goode upon the menhaden. The attempt was now to be made to verify this upon a larger scale and in a systematic manner.

It is believed that in the seasonal variations of the hydro-isothermal lines will be found the key to explain the migrations and the geographical distribution of our important food species as well as of the food upon which they subsist, as both depend upon the temperature variations which determine the changes that occur in their location. It may also happen that while the changes in position of these areas of equal temperature will differ in succeeding seasons, they will, however, stand in some essential relation with the general meteorological conditions upon the land which are under constant observation and discussion. The data eventually obtained will undoubtedly lead to important generalizations bearing upon the questions of physical geography and biological physics, or the relation of marine species to their physical environment.

Our plan of operations was to start at a point south of Nantucket Island, and then running due south, to make a series of soundings, accompanied by a set of observations upon the temperature and specific gravity of the water at various depths. The observations were made by means of instruments attached to a steel-wire cable which was controlled upon the deck of the vessel. These serial-temperature and specific-

gravity observations were made as nearly as possible 10 minutes of latitude apart. To the westward of this first line, a series of such lines were run out from the shore well into the Gulf Stream, at intervals of 10 minutes of longitude. There were nine of these lines, four of which were afterwards duplicated, and upon each of these lines at right angles to the coast there were usually twelve or thirteen stations. Lack of time and the limitations of our craft (it being a sailing vessel) prevented the repetition of more of these lines, which we had intended doing. The position of the instruments upon the cable was determined experimentally, and we finally adopted the following depths: The instruments were placed upon the 5, 10, 15, 20, 25, 30, 40, 50, 75, 100, 150, 200, 250, 300, 400, and 500 fathom points, and thus, with the surface observation, seventeen observations in all were made at all the deep-sea stations; of course in shallower water fewer observations were made, but the intervals between the instruments remained the same.

It will be seen that the instruments were placed closer together near the surface where the changes of temperature were most rapid. By this means we sought to obtain a cross section, so to speak, of the water on each of the lines, which were from 120 to 130 miles long.

In case the work is continued next season, it would be advisable to establish an observing station upon the Nantucket New South Shoal Light-ship, in order that a systematic study may be made of the changes in temperature and specific gravity and also of the atmospheric conditions which accompany them. Such a series of observations is very much needed as a basis of comparison, and a series extending through a whole year and if possible for a longer period would be most useful in connection with the problem which we are studying. At the same time, many interesting observations might be recorded upon the tides, force of currents, etc., as well as upon the movements of the fish. Should it also be possible to obtain the coöperation of a Coast Survey steamer, as has been suggested, to work in conjunction with the *Grampus*, a larger area extending farther to the eastward could be marked out for investigation, but the observations should still conform to the same system of lines running outward from the coast at intervals of 10 miles. As many of these lines as it is possible to run in the course of one month should be completed by the steamer, which should then repeat the same lines during each succeeding month, while the *Grampus* might follow at intervals of about two weeks on some of the lines, perhaps 30 minutes apart, in this manner supplying intermediate series of observations.

In the work of the past summer I was assisted by William F. Magie, PH. D., Assistant Professor of Physics in Princeton College, C. G. Rockwood, jr., PH. D., Professor of Mathematics in Princeton College. and Malcolm McNeill, PH. D., Professor of Mathematics and Astronomy in Lake Forest University. Professor Magie remained with me during the entire season and Professor Rockwood during the first part of the summer, his place on the last trip of the *Grampus* being taken by Professor McNeill. It affords me great pleasure to acknowledge, in this connection, their conscientious performance of duty, their valuable advice and cheerful coöperation, to which is due much of the success of the expedition. I also take this occasion to refer to the valuable assistance rendered by Passed Asst. Engineer W. B. Bayley, U. S. Navy, and Mr. John Maxwell in connection with the fitting out of the vessel; the efficient aid of the officers and crew of the *Grampus*, and the ingenuity and skill of our two engineers, Mr. Lynch and Mr. Rogers.

I have embodied in this report a complete copy of our meteorological records upon the days when we were conducting deep-sea serial observations; the complete record of the series of deep-sea temperatures, together with the observations upon the specific gravity of the water at various depths. Accompanying the report are also a map showing the stations occupied during the cruise with the soundings obtained in each instance, and a series of profiles giving the plotted results of the deep-sea serial temperature observations, upon which the bathyisothermal lines of 50°, 60°, 65°, and 70° F. have been traced. In all 136 stations were occupied, 46 being in water over 100 fathoms deep. A total of over 1,600 observations of temperature of the sea water were made and, in addition to these, 360 meteorological observations were taken each day.

Besides the regular work of the party, Professor Magie took the opportunity of securing observations upon the electric conditions of the atmosphere. His report upon the subject is appended.

While upon the Gulf Stream, during calm weather, in the intervals between observations, the members of the party occupied themselves in collecting the various forms of surface life which floated past the vessel within reach of the dip nets. The material obtained in this manner was referred to Dr. W. K. Brooks, of Johns Hopkins University, whose report is also submitted herewith.

While the results of the past season's operations clearly indicate the importance of further investigations in the same direction, it is still too early to venture upon any extended generalizations. Further data are required to afford a substantial basis for deductions.

DESCRIPTION OF THE GRAMPUS.

The *Grampus* is a wooden, two-masted, keel schooner, built in 1886 especially for the service of the U. S. Fish Commission, being adapted to a wide range of practical and scientific work. Her length over all is 90 feet; width, 22 feet and 2 inches; depth in the hold, 10 feet. Although of comparatively limited dimensions, she is thoroughly seaworthy, and fitted to encounter the heaviest gales. She is capacious under deck, and a swift sailer, especially in fresh winds, having attained a speed of 13 knots and upwards during the past summer.

An idea of her appearance may be derived from the figure published herewith. In general terms, however, it may be stated that she has a sharp bow, with nearly straight vertical stem above the water, the bow closely resembling that of a typical American pilot-boat or British cutter. The midship section is rather full, with a slight "tumble-in" on the top side; she has a long, clean run, symmetrical sheer, and rather deep but gracefully formed elliptical stern. The long, low quarter-deck extends about 3 feet forward of the mainmast, and the waist, including the rails, is 27 inches high; the quarter-rail having the same height as the quarter-deck makes the depth of the waist uniform throughout the entire length of the vessel. A very noticeable feature is the "box well" amidships, in which there is a free circulation of sea water for keeping live fishes and other marine animals.

The arrangement on deck is as follows: A wooden pump-brake windlass, of the kind ordinarily used on fishing vessels of the same size, is located 3 feet forward of the foremast; the forecastle companion is immediately abaft the foremast; 6 feet aft of this is the main-hatch, over which is a booby-hatch or sort of companion entrance to the forehold. Between the main-hatch and the quarter-deck is the "curb" or deck-opening

to the well; immediately aft of the mainmast is the after-hatch, or entrance to the laboratory, which is also covered with a booby-hatch athwartships. On the after part of the quarter-deck is located the cabin trunk or "house," which is 28 inches high, 15 feet long, 12¼ feet wide at the after end, and 14⅓ feet wide at the forward end. The entrance to the cabin is on the port side, aft. The only other deck structure is the wheel-box, which incloses the rudder-head and steering machinery, with the exception of the wheel itself; this is located between the after end of the house and the taffrail.

The cabin is finished in hard wood, and is provided with four extension berths (two located in staterooms), writing desks, table for the cabin mess, etc. Underneath the cabin floor is a large water-tank, with a capacity of about 50 barrels.

Immediately forward of the cabin is the laboratory, which is fully equipped for scientific work and for the storage of specimens and apparatus. It also has a small medical dispensary and closets for the library. It communicates with the cabin through a doorway, and with the forecastle by means of passageways on each side of the well; the deck may be reached directly through the after-hatch, as mentioned above.

On each side of the well, forward of the laboratory, are two pens for the reception of fishing-gear and other accessories. Forward of these, on the port side, is a storeroom for provisions, a pantry-locker, and refrigerator, and on the starboard side a coal-pen. The well occupies the central after part of the hold, immediately forward of the laboratory. Beneath the floor of the forehold are two iron water-tanks, each with a capacity of about 225 gallons. Abaft of and adjoining the forecastle bulkhead are the chain-boxes, extending to the deck, for storing the chain cables.

The forecastle is the forward compartment of the vessel under deck. It is about 23 feet long fore and aft, and in width conforms with the shape of the vessel's bow. It is finished in hard wood, and contains a lavatory for the men, an adjustable table which folds around the mast when not in use, drawers, lockers, cupboards, etc.

The officers of the *Grampus* during the summer of 1889 were as follows: A. C. Adams, captain; E. E. Hahn, first mate; F. S. Conley, second mate; C. H. Wonson ship's writer; William H. Lynch, engineer; James B. Rogers, assistant engineer.

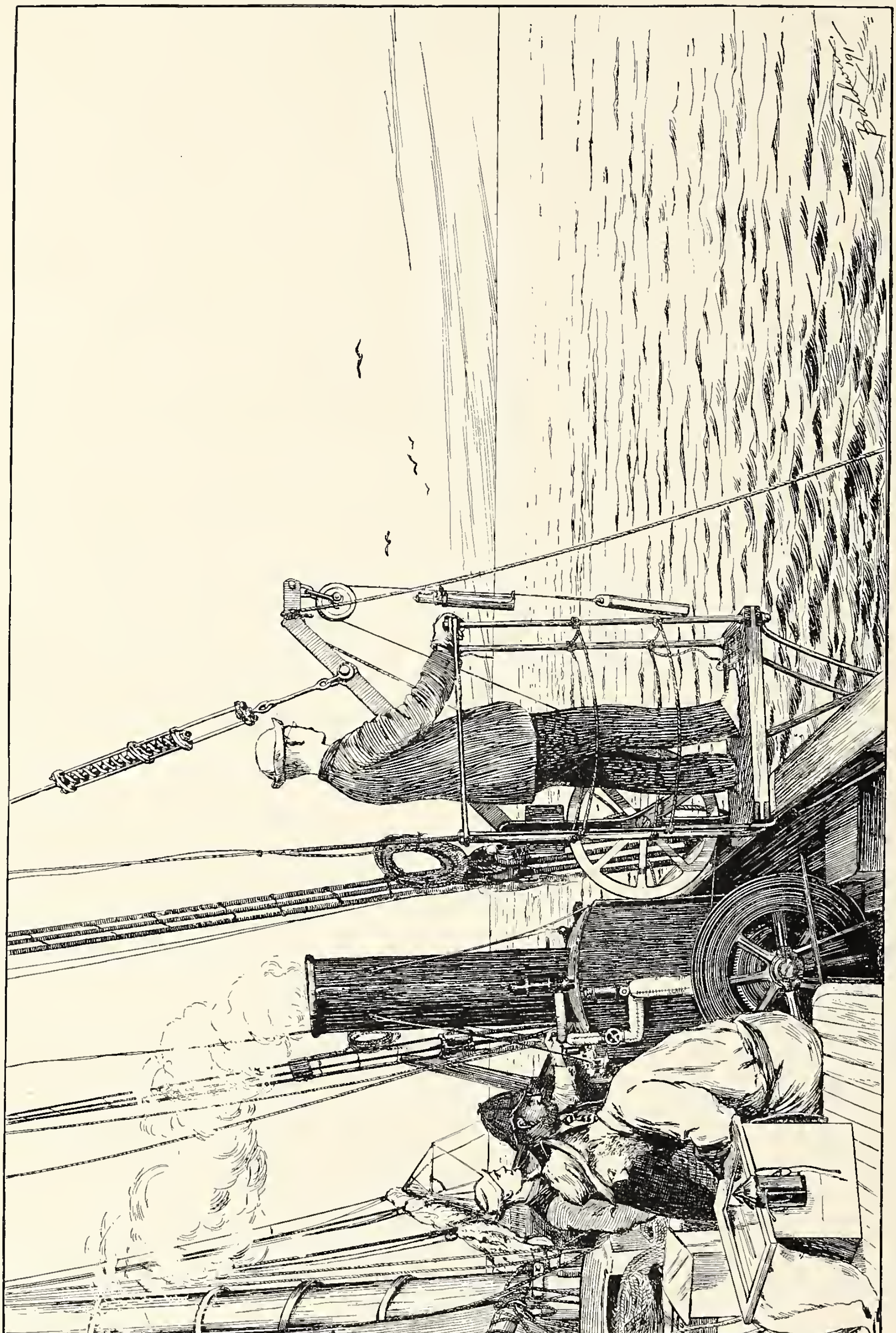
APPLIANCES USED IN THE WORK.

THE SOUNDING APPARATUS.

As a source of motive power, a 6-horse-power Walters reversing-pendulum engine, with a Walters tubular boiler, was used. The grate surface was 5½ square feet, the heating surface 108 square feet, giving a ratio of grate to heating surface of 1 to 19.7. A Wheeler surface condenser, with a Knowles combined air and circulating pump, was also attached, so that no salt water was used in the boiler. The engine and reel were geared together in the proportion of 1 to 2, by a pinion 6 inches in diameter on the engine shaft, and a spur gear 12 inches in diameter on the reel. The engine making two revolutions to one of the reel, the available power was therefore doubled.

The wire cable, one-eighth of an inch in diameter, was composed of 19 strands of No. 24 crucible-steel music wire, and had a breaking strain of 1,500 pounds. It was made especially for this work by Messrs. Washburn & Moen, of Worcester, Mass.

A weight was attached to this wire as a sinker, and the instruments were clamped upon it at various intervals as the wire passed down into the water. The wire led



SOUNDING APPARATUS IN OPERATION.

directly from the reel (containing 1,000 fathoms) to a sheave running between two standards located on the schooner's rail. This sheave had a diameter of 22.8 inches, and one revolution thus corresponded to 1 fathom of wire; attached to the axis of the sheave was a register which indicated the number of fathoms of wire out.

The wire passed from the registering sheave to a small sheave on the end of a davit, extending over the side of the vessel. The davit arm was attached to the standards containing the registering sheave by a pintle, which allowed the davit to be swung inboard or outboard, and also by a joint which permitted the davit to be raised or lowered, thus regulating the distance of the wire from the side of the ship. The outer end of the davit was hung from the main cross-trees by an accumulator consisting of two steel springs, one resisting a pressure of 300 pounds and the other 600 pounds, which served to relieve the strain upon the wire caused by the motion of the vessel.

Just abaft the standards of the davit, upon the rail of the vessel, a platform was built, where an observer stood to fasten the instruments upon the cable as it descended and take them from it and read their indications as it was reeled in.

The apparatus was all placed upon the starboard quarter-deck of the vessel.

METEOROLOGICAL INSTRUMENTS.

(1) *Barometer.*—The barometer used was of the ordinary marine form with the lower portion of the tube of a small diameter. It was graduated to read 0.002 inch. During the summer the instrument hung in the laboratory of the schooner, the cistern of the barometer being on a level with the water line of the vessel about midships.

(2) *Thermometers.*—(*a*) The thermometer used for the observation of the temperature of the air was an instrument constructed with the greatest care. It was placed upon an ivory frame, which was mounted so as to keep the instrument at a distance of 1½ inches from the board upon which it was hung. The position of the thermometer was horizontal.

(*b*) The temperature of the surface water was obtained by drawing a pail of water from over the side of the vessel, placing it in the shade, and allowing the thermometer to remain in the water from two to five minutes, dependent upon circumstances. During the trip we used the Wilder protected thermometers with brass scale and copper case. Our set at first consisted of three of these thermometers, one of which, No. 6795, was lost early in the trip.

(*c*) Dew-point thermometers: This set consisted of two thermometers mounted upon the same metal frame, one of which was supplied with water from a glass tube fastened to the back of the frame, as in Mason's hygrometer.

(*d*) The maximum and minimum thermometers were of the ordinary construction, the maximum being a mercurial thermometer in which a small part of the mercurial column was separated from the rest and served as an index. The minimum was an alcohol thermometer with a metallic index. In addition to these a Six's maximum and minimum thermometer was also used, but its indications were very unsatisfactory.

(*e*) Observations upon the rainfall and evaporation were made by means of a Symons rain gauge and an evaporating dish. The rain gauge had a 6-inch collecting funnel which led into a bottle strongly protected by a zinc casing, into which the funnel fitted as a cover. The evaporation dish was also 6 inches in diameter. It was 2 inches deep and was covered by a coarse wire network. These instruments were exposed at the stern of the vessel just above the gig.

(*f*) A solar radiation thermometer and a spirit minimum thermometer were also used in the open air. They were freely exposed to the sun and weather, suspended by cords in such a way as to be as free as possible from the effect of the motion of the vessel, and were placed between the davits of the gig at its stern.

(*g*) Two portable air meters were also used, one with a 5-inch opening and the other with a 3-inch opening. These were used when the vessel was hove to upon a station to observe the difference in velocity of the wind upon the deck and at various heights in the rigging.

(*h*) An ozonometer, consisting of a wire cage in which the prepared papers were exposed, was also utilized, but no observations were obtained which indicated the presence of ozone in the air, with the exception of one single day, on which the slightest tinge of purple was observed. This cage was exposed with the other instruments at the stern of the vessel.

All the above instruments, with the exception of the barometer and those included under the last four heads, were exposed in a case prepared especially for them, which served its purpose so well that a description of it is warranted and will be given below. The above instruments were all made by Mr. G. Tagliabue, of 302 Pearl street, New York City, and he exerted himself to the utmost to secure great accuracy in them, knowing the use to which they would be put.

Thermometer case.—This case was a strongly constructed box 3 feet long by 2 feet wide and 2½ feet high at the front and back; it had a ridged top or roof, which served to shed the rain, making the central portion of the box 3 feet high. The lower foot in height all around the box was closed, but the upper portion was composed of a lattice of louvre boards to allow a free circulation of the air. The box was secured firmly to the deck just aft the cabin deck house. From the center of the ridge on the inside of the pent house a board was suspended by gimbals, and on this board, but kept at a distance of 1½ inches from it by proper supports, the instruments were placed and secured by hooks. From the lower edge of the board directly below the gimbals a 10-pound weight was suspended. This device secured the instruments in a practically horizontal position, because none of the movements of the vessel affected them in the least.

INSTRUMENTS FOR SERIAL TEMPERATURE OBSERVATIONS.

The instruments used for this work were made by Negretti & Zambra, and were fitted with the Tanner deep-sea case and reversing apparatus. Our set consisted of twenty-five of these instruments, and they were placed in a strong pine box upon the deck, where they would be convenient to the observer when wanted. The box was constructed like a trunk, with two trays and an open bottom space the same size as one of the trays. These trays were divided into spaces by a series of strips, across which a piece of canvas was stretched in such a manner that it served as a support for the instruments. They were thus protected from all sudden jars, and were very accessible. In shallow water the upper tray, containing a water cup, a hydrometer, a salinometer cup with thermometer attached, and eight deep-sea thermometers (which were all that were necessary), was exposed by opening the box. In the deep soundings, and when serial observations were made extending to 500 fathoms, where sixteen thermometers and two water cups were used, the upper tray was removed when empty

and the necessary thermometers taken from the tray below. The bottom space was filled with thermometers held in reserve in case of accidents occurring, but it was never opened except to care for the thermometers.

INSTRUMENTS FOR SPECIFIC-GRAVITY OBSERVATIONS.

These observations were made with the Hilgard ocean salinometer. The specimens of water from the surface were obtained in the ordinary manner. The specimens from the bottom or from any desired depth were obtained by means of a Sigsbee water-cup.

INSTRUMENTAL CORRECTIONS, REDUCTION OF OBSERVATIONS, ETC.

The specific-gravity observations, made with the Hilgard salinometer, were reduced by means of the table given for that purpose in the original description of the instrument, as published in Appendix 16 of the U. S. Coast Survey Report for 1874, and found on page 155 of that volume. This table may also be found on page 78 of the Report on the U. S. Fish Commission steamer *Albatross* in the Annual Report of the Commissioner of Fish and Fisheries for 1883, and is again reproduced below with an alteration to be noticed immediately. It is based upon the observations of the expansibility of sea water made by Prof. J. S. Hubbard, U. S. Navy. In making use of this table Professor Rockwood's attention was at once attracted by the irregularity in the resulting corrections for temperature between 59° and 61°, and further examination led him to conclude that the tabular number for 60° was erroneous and should be 0.000125 instead of 0.000000. This conclusion being concurred in by Mr. O. H. Tittman, of the Bureau of Weights and Measures of the U. S. Coast and Geodetic Survey, the table as given differs from the original table by the substitution of $0 \mp .000125$ for $+0.000000$ as the tabular number for 60°, where the minus sign is to be used with temperatures below 60°. To facilitate the use of the table the following directions are given:

Record the actual observation of hydrometer and thermometer. From column II take the number corresponding to the observed temperature and multiply this number by the number of degrees and fractions of a degree that the observed temperature differs from 60°. Apply this product as a correction, with proper sign, to the reading of the salinometer and the result will be the reading of the salinometer at the standard temperature of 60° F.

Temp.	Correction for reduction to 60° F.	Temp.	Correction for reduction to 60° F.	Temp.	Correction for reduction to 60° F.	Temp.	Correction for reduction to 60° F.
I.	II.	I.	II.	I.	II.	I.	II.
° 50	−0.000108	° 60	+0.000125	° 70	+0.000145	° 80	+0.000158
51	−0.000110	61	+0.000130	71	+0.000146	81	+0.000159
52	−0.000112	62	+0.000135	72	+0.000147	82	+0.000160
53	−0.000113	63	+0.000137	73	+0.000148	83	+0.000162
54	−0.000115	64	+0.000137	74	+0.000149	84	+0.000163
55	−0.000118	65	+0.000138	75	+0.000151	85	+0.000164
56	−0.000120	66	+0.000140	76	+0.000152	86	+0.000166
57	−0.000120	67	+0.000141	77	+0.000154	87	+0.000167
58	−0.000120	68	+0.000142	78	+0.000156	88	+0.000168
59	−0.000120	69	+0.000143	79	+0.000157	89	+0.000170

But as it was desired to employ 4° C. as the standard temperature instead of 60° F. and that the reductions be made to 15° C. in place of 60° F., a further correction was necessary. This correction is constant, and its amount as determined by Mr. O.

H. Tittman, of the U. S. Coast Survey, and adopted by both the Coast Survey and the Fish Commission, is —0.00082, which is therefore to be subtracted from each specific gravity determined by the above table and the result will be the specific gravity referred to a temperature of 4° C. as a standard.

Example: Station No. 1, at depth of 13 fathoms the reading of the salinometer was 1.0248, and the temperature 61.9° F.

Tabular number for 61.9°	0.0001345
Difference of temperature from 60°	1.9
	12105
	1345
Correction to 60° F	+0.00025555
Correction from 60° F. to 4° C	—0.00082
Total correction	—0.00056
Observed specific gravity	1.0248
Reduced specific gravity	1.02424

I am indebted to the kindness of Professor Rockwood for the reduction of all the specific-gravity records of this report; all other corrections or reductions are my own.

Negretti and Zambra's deep sea thermometers—corrections.

[These instruments were compared with the standard instruments of the U. S. Signal Service in May and June, 1889, with the corrections noted, with the exception of No. 52728, which was compared with the standard instruments of the Fish Commission on December 4, 1884.]

Number.	32°	42°	52°	62°	72°	Number.	32°	42°	52°	62°	72°
52728	—.5	—.2	—.3	—.3	—.2	66661	—.1	—.1	—.2	—.1	—.1
62365	—.3	—.1	.0	+.1	.0	66663	—.4	—.1	—.1	—.1	—.1
63911	—.1	—.4	—.1	—.2	—.3	66664	+.1	—.1	.0	—.1	—.2
63914	+.1	+.1	+.1	.0	.0	66665	.0	—.2	—.2	—.3	—.3
63916	+.1	+.1	+.1	.0	+.2	66724	+.1	+.1	.0	—.1	.0
63918	.0	.0	+.1	.0	+.1	66726	.0	—.1	—.2	—.1	+.1
63919	+.1	.0	.0	.0	.0	66728	+.1	.0	.0	.0	—.1
63920	.0	—.2	—.1	.0	.0	66729	.0	—.1	—.2	—.1	—.1
63921	—.2	—.3	—.1	.0	+.1	66731	—.1	—.1	—.2	—.1	.0
66656	.0	—.3	—.2	—.1	—.3	66733	.0	.0	—.1	—.1	—.1
66658	+.1	—.2	—.2	.0	—.3	66734	.0	.0	—.1	—.1	—.1
66659	.0	—.3	—.3	—.2	—.1	66737	.0	—.1	—.2	.0	.0
66660	.0	—.4	—.3	—.1	.0						

Corrections for the set of meteorological instruments.

Standard.	1889.	1890.	1894.		1895.	1896.	Solar.
	Min.	Max.	Wet bulb.	Dry bulb.	Air.	Radiat.	
32°	.0	.0	.0	.0	.0	.0	.0
52°	—.1	.0	.0	.0	.0	.0	+.5
72°	.0	.0	—.1	—.1	.0	.0	.0
92°	.0	.0	.0	.0	.0	.0	+.2

The marine mercurial barometer which was used was tested on June 28, 1889, at the New York Branch of the Hydrographic Office and found correct.

The hydrometers used were carefully tested in the Physical Laboratory at Princeton by Professor Magie, and found correct, far within the limits of errors due to observation, and are thus regarded as giving correct data.

DISCUSSION OF THE RECORDS.

MANNER OF KEEPING THE RECORDS.

The observations were recorded in a book especially prepared for this work, in which four pages were allotted to each day's work. The first page was devoted to the meteorological record for the 24 hours and was divided as in the appended tables. The second page was devoted to the record of serial-temperature and density observations; the third page was reserved for general observations of a scientific nature, and the fourth contained an abstract of the log. This record book was placed in a box upon the top of the deck house, and the box was so arranged that observations could be recorded in the book at all hours and in all sorts of weather without exposing the records to the risk of blurring. The top of the box was glass and had a slight inclination away from the observer, in order to throw the rain in that direction. The side next to the observer (with the exception of a 2-inch strip of wood at the bottom) was canvas, with two holes in it opposite the center of each page in the record book. Through these the hand was passed in making the record. These openings were covered when the box was not in use by a flap of canvas which could be securely buttoned down over the end of the box. The glass top was also covered with a flap of canvas to protect the rulings of the book from the action of the sunlight. At night the interior of the box was illuminated by a lantern placed at the left end.

THE METEOROLOGICAL RECORDS.

July 24, 1889. (Table 1 and Plate 1.)—We commenced work upon line A, south of Nantucket. (See map.) The air curves (Plate 1) of the temperature of New York and Boston follow one another very well, the effect of more northerly latitude being seen in the much lower depression of the curve when there is a decline in the temperature.

The decrease in temperature on the *Grampus* in the a. m. is probably due to the influence of the water, as we were leaving shoal and inshore waters, which were warm, and passing through cold surface water until 11 a. m., when we reached much warmer water. This will be clearly seen from the curves on the same plate, which contrast the temperatures of the air and water for the same day.

The maximum air temperature on the *Grampus* is reached at 3 to 4 p. m., and seems to show an utter disregard for the disturbance which is going on upon the land. There is a long steady decline until 10 p. m. The sudden rise at this point can be again explained by reference to the curves of the air and water temperatures, the water curve being particularly instructive. After the lowest surface temperature was reached at 11 a. m., there was a rise in the water temperature of 4° F. each hour for 2 hours, a change which could hardly be due to the sun's influence in so short a time. Of course the air temperature was somewhat modified by this condition of the water. It will also be seen from the records that there was a decided increase in the specific gravity of the water (1.0241 to 1.0249 and 1.0253). The effect of the warm midday sun upon a body of water which originally had the same temperature is seen from the curve between 1 p. m. and 5 p. m., where its gradual cumulative influence is apparent, although the temperature of the air at the same time had commenced to fall, and the decrease in the surface temperature after 5 p. m. is probably due to the with-

drawal of this influence. At 22 hours (or 10 p. m.) a band of still warmer water was reached, which also had a high specific gravity, and its influence is instantly noticed in both air and water temperature curves. The temperature of the air, with a perfectly clear sky, would naturally have decreased at this time of the night had it not been for the increase of temperature in the water.

July 25, 1889. (Table 2 and Plate 2.)—From the point reached at midnight the temperature of the water increases in general until noon, from which time it decreases gradually. The effect of a heavy rain squall is noticed at 7 a. m. in the fall of the air curve, and also in the arrest of the upward tendency of the water-temperature curve. Two rainfalls in the p. m. keep the air curve well below that of the water. The same effect is noticeable in the contrasts of the three air curves for the p. m. Little was done in the forenoon of this day owing to an accident, but in the afternoon and evening, finding we had drifted to the westward, we started upon the line C, returning toward the shore.

July 26, 1889. (Table 3 and Plate 3.)—We were well upon our return trip on line C. The high temperature of the air was probably due to warm water, a heavily overcast sky, and almost no wind. These conditions were reversed at noon by a fog springing up, followed by a freshening breeze from the east. Similar conditions seem to have prevailed on the land, as shown by the air curves. The decrease in the temperature of the water as we left the warmer and more dense bands of water and approached the shore is quite evident.

The next few days were spent in Wood's Holl, making some changes in our apparatus which this trial trip had shown to be necessary.

August 1, 1889. (Table 4 and Plate 4.)—We started outward upon line F. The effect of strong wind currents is seen upon the maximum portions of all the curves. On the *Grampus* the wind was strong (5) at the hours 14, 17, and 19, and was from the SSW. Its result was naturally first evident upon the New York curve, and a little later upon both the curves of the *Grampus* and of Boston. The coincidence of the times and the directions in these latter curves is quite striking; the rebound in each temperature curve after the gust of wind had passed is a pronounced one in each case, particularly so in the Boston curve at 14 hours, where the land midday temperature reasserts itself most decidedly. The water curve shows an increase in temperature throughout the day and well into the night. The warmer temperature of the air can only be accountable for a small portion of the increase at midday.

August 2, 1889. (Table 5 and Plate 5.)—Early this a. m. (4 hours) the water became too rough to allow us to prosecute our regular work to advantage, so we headed for the shore, which we sighted about 10 o'clock. Then a line was commenced parallel with the coast towards Block Island, and four stations were made upon it before we ran into Block Island Harbor for the night.

I have failed to find an adequate cause for the decrease in the temperature of the water upon this line as we passed the entrance to Vineyard Sound and Buzzard's Bay (11 to 13 hours), and again as we passed across the entrance to Narragansett Bay towards Block Island (17 to 18 hours), unless the tides have some effect upon the local temperature through changes produced in position in water masses. In the first instance it was just high tide; and in the latter, low tide. The effect upon the air temperature, with an overcast sky, of strong gusty winds is seen at 11, 13, and 16 hours, and this curve is in marked contrast with the air curves at New York and Boston.

August 3, 1889, we were storm-staid in Block Island Harbor.

August 4, 1889. (Table 6 and Plate 6.)—We started another line to the eastward. The same depressions in the temperature curve of the water were noticed, although we were 10 miles further offshore than on August 2, and the temperatures were recorded in the p. m. on August 2 and in the a. m. to-day. When we started on this line it was high tide, and when we reached line G it was low tide, exactly the reverse conditions of August 2. These depressions will be noticed at 7 to 9 hours, as we crossed the entrance to Narragansett Bay, at 11 hours off Buzzard's Bay, and at 14 hours off Vineyard Sound. The temperature curve of the air does not show any marked differences from those of New York or Boston, except those due to the general influence of the ocean, which would naturally cause a lower temperature. At 18 hours we notice a depression in the water curve caused by our taking an outward course along line E and passing through colder water. After this was passed the temperature rose again as we reached warmer and denser water.

August 5, 1889. (Table 7 and Plate 7.)—On the *Grampus* the conditions of the water remained nearly unchanged until 9 a. m., when the wind commenced to blow strongly, and this was followed by a heavy rain. At 11 a. m. we were struck by a severe squall, which forced us to lie to under the mainsail. The sudden drop in the air curve will of itself explain why we headed for shore again. The fall in the water curve as we entered the cold band off the coast is clearly seen. The meteorological conditions at New York and Boston appear to have been decidedly mixed, and offer some explanation of our treatment upon the ocean between these points.

August 6, 1889. (Table 8 and Plate 8.)—The air temperature of the *Grampus* follows the curve at New York in the main. The Boston curve apparently was affected by some cause which may have hindered the full development of our curve in the a. m., and also may have hurried the descent of the curve in the p. m. We spent nearly the whole day "jogging" off Martha's Vineyard for lack of wind. The only break in the water-temperature curve which needs explanation occurred at 13 hours, when we had nearly reached the entrance to Muskeget Channel (Station D 1) just before high tide. The contrasts given in the air and water curves during the entire day can be taken to represent the effect of the sun upon the shoal water near the coast, since we hardly varied our position by more than 10 miles all day long. The sky was nearly covered with clouds all the a. m. and in the late p. m., but at 15 to 17 hours, when the clouds were least, the highest temperature was reached. The increase in temperature was soon overcome when the sky was covered again and the temperature of the water became the controlling element.

August 7, 1889. (Table 9 and Plate 9.)—In the early a. m. the same general conditions prevailed. During the day the *Grampus* air curve reached the same maximum as reached by the New York air curve. This was due to the high water temperature, clouded sky, and exceedingly light winds. It is noticeable that an increase in the water temperature took place quite early in the a. m. and the maximum was reached at 13 to 15 hours, when we had a light specific gravity (1.0251, Station D 3). The long continuance of the high temperature into the night hours at New York is noteworthy, and was probably due to westerly continental winds.

August 8, 1889. (Table 10 and Plate 10.)—A day of extraordinary changes in the air temperature. The *Grampus* air curve reached a higher point than the New York curve, the maximum occurring before noon. Unless this day's curves be taken

to represent easterly and northeasterly weather, as contrasted with the westerly weather which was shown in yesterday's curves, they are hard to explain. Even this explanation might not hold good for the conditions nearer the coast, because, as will be seen from the water curve, we were passing through a very distinctly warm band of water from 9 to 13 hours (73.4° F.), and the specific gravity was also high (Station D 9, sp. gr. 1.0260). This, taken with the fact that the wind was blowing with about a force of 4 from the northeast, complicates the problem very much.

August 9, 1889. (Table 11 and Plate 11.)—We completed line D in the a. m., but after starting line E with three stations the water became so choppy that we were forced to head for the shore after finishing Station E 11. The covered sky, warm water, and westerly winds account for the height of the air curve, which follows the curves of New York and Boston pretty well, the disturbance set up by the westerly wind being most strongly felt in New York, next on the *Grampus*, and last of all in Boston, as was natural. The rise in the water-temperature curve between 8 and 11 hours as we were moving westward in the Gulf Stream is interesting, although it was undoubtedly accentuated by the atmospheric conditions.

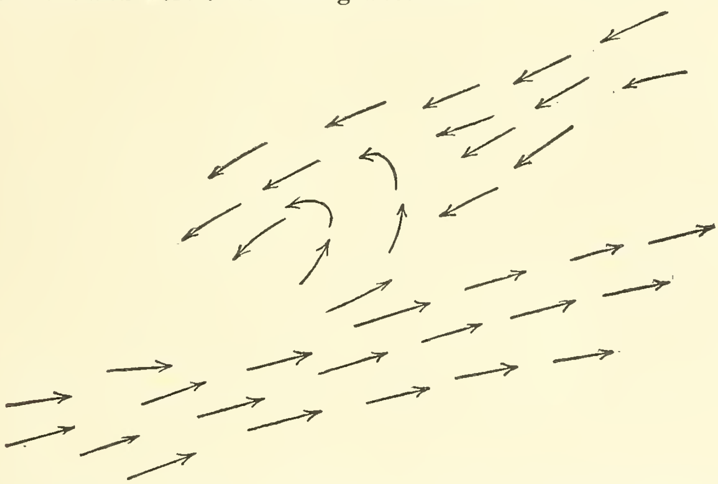
We went in to Wood's Holl, where we were detained 4 days by stormy weather.

August 17, 1889. (Table 12 and Plate 12.)—We left Wood's Holl on August 16, but were forced to put back into Tarpaulin Cove on account of rough water.

The wind was very light in the a. m. of August 17, and it took us until noon to reach Station G 2. We passed into warm water again between G 3 and G 4 at 15 hours, after which time the air and water curves follow one another very closely. In the contrast of air curves all is normal until 19 hours, when the air curve of the *Grampus* stops in its downward course and the influence of the warm water upon the air temperature places the curve in strong contrast to those of New York and Boston.

August 18, 1889. (Table 13 and Plate 13.)—The irregularities observable in the contrast of the air and water are partly accidental; for example, that at 8 hours was caused by the fact that our thermometer box was directly exposed to the strongest glare of the sun across the deck in the direction of the louvre openings in its sides. This condition was corrected upon noting the reading. Then there are two depressions, one at 8 hours and the other at 12 to 14 hours, which show the result of cloudless sky followed by clouds at these hours. The maximum water temperature was reached at 15 hours, station G 12 (74.5° F.) accompanied by a specific gravity of 1.0257. The air and water curves as contrasted in the p. m. show the result of heavy clouds upon the temperature of the air. The contrasts of the air curves upon the *Grampus* and those of New York and Boston are very nicely shown when allowance is made for the variations noted above. The *Grampus* curve would present a comparatively slight range, while the land curves would give most decided maxima and minima. It will be seen by a glance at the column containing the list of stations that we were still upon line G, in continuance of our work of the previous day. Upon comparing our plotted line (by log record) with our observed latitude of yesterday at 16 hours, station G 4, No. 61 (see also map of stations), we found that we had drifted to the westward. The wind force only enabled us to creep along and we were thus fully exposed to the action of the currents as we slowly worked across them. The drift to the westward was such as might have been expected, for we were undoubtedly in a part of the ocean where the cold current would take us in that direction, but we

were in a body of warm water (70.4° F.) with a high specific gravity (1.0250). The only explanation possible was that we were in some of the warm outer bands of the Gulf Stream, which after being separated from the main current had been overpowered by the cold current and were thus moving westward.



This state of affairs would be possible under the conditions which we found to exist, and which will be fully shown and discussed in connection with the section profiles of serial temperatures which accompany this report. These profiles indicate that the warm surface water of the Gulf Stream has been pushed farther inshore than is usual, for some reason or other, or perhaps a portion of it has been impelled over the surface of the cold current. Upon examination of the monthly maps of the Hydrographic Office since our return, I am convinced that this condition has been caused by long-continued winds from the southeast. Fortunately the same conditions, as far as wind was concerned, lasted long enough for us to test the matter slightly. At our next observation for latitude, station F 10, No. 67, was shown to be our position (see map), thus placing us to the eastward, as we would naturally expect to be when our course was so largely controlled by the currents of the main Gulf Stream. It is well to note that by the log record we were sailing a true south course all the time. This rather remarkable occurrence would not have been detected had not the conditions been so favorable, and further, from the fact that we were in a sailing vessel, which, of course, was completely at the mercy of the currents as long as we merely had wind enough to give us headway. These facts would never have been noticed in a steamer, unless especial pains had been taken to study the surface currents, and it is hoped that this mention of the subject will lead to a more careful study of those outlying streams of warm water, for it will be seen that if they exist under favorable conditions, or disappear under other conditions, they may cause the irregular distribution of the food which is followed up by the schools of fish. Our line had become so irregular that we decided to return on line J.

August 19, 1889. (Table 14 and Plate 14.)—If the wind had continued at the same rate it was our intention to have verified the explanation suggested above upon our return trip, but the wind increased in force and we were deprived of the opportunity. The water temperature, under an almost open sky, with moderate and steady

winds, freshening towards evening, gives a long, regular curve. The air curve shows the effect of the clouds of yesterday p. m. until 6 hours, when the same contrast with the New York and Boston curves appears as was shown in the case of yesterday.

August 20, 1889. (Table 15 and Plate 15.)—We reached the shore end of line J (J 3, No. 81) at 6 hours, went to the westward and commenced line K with K 3, No. 82, and then proceeded southward along that line. The fact that we were going inshore from warm to cold water and then out again from cold to warm water is well shown by the curves between 5 and 12 hours. The influence of the warm water upon the air after 12 hours is clearly shown, as it was intensified by a thick mist between 13 and 18 hours, during the time in which the elevation of the curve became so pronounced. The Boston curve is abnormal, but no explanation is at hand for this fact.

August 21, 1889. (Table 16 and Plate 16.)—The air and water curves follow one another very well except at 7 hours, where the sudden rise was due to the rays of the sun striking the side of the thermometer box directly. This was also the case between 10 and 18 hours, where the greatest increase in the temperature is noticed. Curiously enough this part of the air curve follows the New York curve closely. The water temperature was very high during all this time, reaching a maximum of 76.2° F. at 15 to 16 hours, while we were going eastward from line K to line H. At station K 12, No. 91, the specific gravity was 1.0259, and at station H 12, No. 92, it was 1.0258. An almost total lack of wind, the warm water, and the impossibility of protecting the thermometer box from the sun's rays while moving to the eastward is a sufficient explanation for this abnormal air curve.

August 22, 1889. (Table 17 and Plate 17.)—The sudden increase in the air temperature was again due to the sun's rays upon the thermometer box. From 8 hours onward we were surrounded by a thick haze, and from 12 hours onward we had no wind to speak of. From the fact that we supposed we were passing up line H (see map) and found that G 7 was our position at 9 hours this a. m., and then that the plotted log would not bring us far enough to the westward to reach the position we occupied in the p. m., we have reason to believe that there is some probability in the theory advanced in connection with the work of August 18. The descent in the water curve as we approach the cold waters of the shore is again apparent. We went into Wood's Holl to refit and replenish our stores and were there for three days. On August 27 we started again and were forced back to Newport by the rough water. We made two attempts to renew our work, but were not successful until August 31.

August 31, 1889. (Tables 18 and 19 and Plate 19.)—We made a beginning upon line K, but were forced to give it up and run back at midnight on account of the high wind and rough water. The long-continued heat, as shown by the New York curve, is noteworthy.

September 1, 1889. (Table 20 and Plate 20.)—The attempt this a. m. was made upon line J with the same result. Not enough work was done to make records of any value. The meteorological records and plates are given simply because of the stations recorded in the course of the work.

September 2, 1889. (Table 21.)—Nothing could be done until evening, when we started upon line H. We reached open water at 19 hours, and our meteorological record began at this time, giving too short a record to warrant a plate. The first station, H 1, No. 114, was reached at 23 hours.

September 3, 1889. (Table 22 and Plate 22.)—The air curve on the *Grampus* evidently participated in the general movement which was going on, as shown by the air curves. The increase in temperature, as shown by the water curve at 15 hours, is very sudden, although a general increase was noticeable all through the a. m. from 4 hours onward at station H 3.

September 4, 1889. (Table 23 and Plate 23.)—The sun's rays were on the box again at 14 hours, but this would not account for all of the midday elevations, as there was a decided rise in the temperature before this time. The great irregularity of the water curve is striking, though in general it is high, as is to be expected in this region. The great coincidence of all the air curves is rather remarkable.

September 5, 1889. (Table 24 and Plate 24.)—The sun was on the thermometer box from 10 to 17 hours, as we were sailing due north, and thus on this day the air curve eclipses those of both Boston and New York. There were no clouds except in the a. m., and this must have had some effect upon the water temperature, but it is hard to believe that it was as decided as indicated by the water curve between 12 and 18 hours, though it is possible.

September 6, 1889. (Table 25 and Plate 25.)—A cloudless day and with very little wind. The sun's rays were upon the thermometer box again from 8 to 12 hours, and the air curve once more follows the New York and Boston curves closely. The water curve commenced to go down last night, and the descent continued until station G 2, No. 136, was reached, when we were in shoal water offshore, and should expect a rise in temperature on such a hot day so near the shore.

We went into Wood's Holl after this, and severe storms prevented our making any more trips, thus closing the work for the season.

THE RECORDS OF SERIAL TEMPERATURES AND DENSITIES.

In the preparation of the plates which illustrate this portion of the report, only such of the lines were used as were completed within a reasonably short time of one another. It would not be right to place upon the same profile sheet observations made at intervals of several days, since changes produced in just such intervals were the subject of our study. We were able to complete but seven separate lines at right angles to the coast, within what seemed satisfactory time limits (36 to 48 hours). Two of these lines (G and H) were repeated under the same conditions, and hence only these nine profiles are given. Further, it would not be proper to compare too closely all of those charts with one another, because they were made at such wide intervals of time that the connection between them is broken through a change in season and other conditions. The most important series were those made along lines G, H, J, and K, which were completed between August 17 and September 6. During this period we were favored with good weather and were enabled to complete four lines and repeat two of them. The six profiles representing these lines are given first. The other three profiles represent the lines farther to the eastward and lose some of their interest from the fact that we were not able to repeat any of them during the season on account of the weather. Furthermore, while we were making these latter lines, we were experimenting upon the proper location, or the best intervals upon the wire, for our thermometers. It will be seen later on that we missed one very prominent feature in the temperature relations in our early work from this fact.

These six profiles, however, are worth all the summer's work—because they give us a fair outline of the subject in hand. They are very suggestive of inquiries to be pushed further; and, having these, more careful attention can be given to the study of the details of the temperature areas in another season.

In some respects we were working in the dark. We knew nothing except the general laws given by the study of isolated series of temperatures and densities. The relations which are supposed to exist between the cold current and the Gulf Stream are sufficiently vague to please or puzzle as the case may be. We have perhaps obtained clearer views upon this subject, but in any event, in spite of the lacunæ which have been developed in our work by the plotting and study of the data we collected, we have enough information to lead to profitable investigation in the coming summer. It is true we may not find the same distribution of temperature areas, and if we do not the further problem of why the changes have occurred will become a fruitful source of inquiry.

It will be noticed that our serial temperatures in deep water reached to a depth of 500 fathoms (see records). We were sure that at this depth we would be beyond the region of fluctuations, as the changes noticed below this point are very slight. The observations show that we could have stopped at 150 or 200 fathoms, and have been perfectly safe—but we were afraid of missing some element in the study of the temperatures, and preferred to drag a deep net rather than lose it. One thing would have been desirable, viz, a more systematic and extended study of the specific gravities at the various depths, particularly at the edge of the continental platform. We had no reason to suspect the existence of certain facts which struck us as peculiar when our work developed towards the latter part of the summer, and if we had been able to give a little more time to the work we should have tested these conditions more carefully. One more line out and back would have been a great consolation to us, but it could not be; and it was well that we did not attempt this last trip, as it is doubtful whether the results obtained in such bad weather as was experienced after our work closed would have been of much value.

It will be seen by reference to the map of stations occupied by the *Grampus* during the summer that many other parts of lines were made, but these were not of sufficient length to give any additional light upon the subject, and hence have been omitted. They do not influence the results one way or the other. If they had crossed the edge of the continental platform they would have been interesting, but they are generally fragments at one end or the other of lines, and sometimes these portions, even if they happened to be upon the same line, were made at dates too widely separated to be of any value for our purpose; their omission is therefore no great loss.

The scale adopted, about 1 in 350, may seem excessive, but after many experiments it was chosen because the features of the temperature curves were best shown by it.

The profiles do not give the temperatures or specific gravities below 150 fathoms, as these will be seen from the records to vary but little below this depth. All the data collected, however, have been published in tabular form in the records, for future reference.

In the profiles the bathyisothermal lines of 70°, 65°, 60°, and 50° have been given in the first four charts, and in the others only those of 70°, 60°, and 50°, as these lines develop the principal features of the temperatures in each instance.

In every chart the rather remarkable curvature of the 50° line downward off the continental platform will be instantly noticed.

In the first charts this line extends seaward from the edge of the continent for some distance, then returns toward it again, follows it downward for some distance, and then passes out toward the main body of the ocean. It would be interesting to notice whether it returns toward the surface of the ocean again at some point farther along the line. This body of comparatively warm water has an average depth of about 50 fathoms and has a most peculiar shape, as will be seen from a comparison of the several charts. We refer now particularly to the first five, since our data were not sufficiently numerous in the other charts to enable us to verify the existence of this same form of the body of water referred to in the earlier lines. The modifications in the outline of this mass of water take place in its upper portion, particularly in the upper part lying opposite to the continental edge. Where the slope of the platform is slight, as in charts 1 and 2, it is gradually rounded in this portion, but in charts 3 and 4, where the slope is more abrupt, this rounded part is broken into and the water massed to a greater height beyond it farther seaward. This does not hold good of chart 6, where local influences may produce a different result. Just why this is so we are not able to state, because no perfect lines were made directly to the eastward of this line.

The peculiar shape of this curve would seem to point to a mechanical intrusion of cold water from the surface of the continental platform, which may be reinforced by the specific gravity of the water, as would appear from a study of some of the observations made, notably the specific gravities at the 100-fathom line in charts 2 and 3.

The existence of this body of warm water off the continental edge may offer an explanation of the richness of this particular spot in all forms of marine life, as shown by the successful dredging of the *Albatross* upon it.

The curves of 70° in the first four charts, if studied in succession, remembering that they were made at intervals of 10 minutes of longitude to the eastward of one another, show very nicely the gradual breaking up of a broad belt of warm water in chart 1 into several distinct smaller bands in chart 4. The proximity of the northernmost end of this line to the coast on charts 1, 2, 3, and 4 points very strongly to the influence of long-continued winds in driving this body of water toward the coast. The contrast in the position of the shore end of this line in charts 5 and 6 is very striking. These lines are a repetition of the lines of charts 3 and 4, made two weeks later, after an interval during which strong northerly winds were constantly blowing. The first-mentioned charts (Nos. 1, 2, 3, and 4) were made after the winds from the south, which had been at work nearly all summer, had about reached the maximum of their influence.

Further than this in the interpretation of our data we dare not go at present. Enough has been said to call attention to the interesting nature of the problem we are working upon, which has not yet been solved. The facts pointed out warrant further investigation, and it is hoped that the work of the coming year may bring us one step nearer the accomplishment of our wish.

REPORT UPON ATMOSPHERIC ELECTRICITY.

BY W. F. MAGIE, PH. D.

Professor of Physics in the College of New Jersey, Princeton.

The observations on atmospheric electricity presented in the following report were made by the author during the summer of 1889 on board the U. S. Fish Commission schooner *Grampus*, while he was engaged in assisting Professor Libbey in the investigation of ocean temperatures. The duties of the regular work were so exacting that no systematic record of the atmospheric electricity was kept; but the observations were made to decide whether such a record would be valuable. On this point the observations, few as they are, leave no question. It is stated by Exner, in his elaborate paper, Ueber die Ursache und die Gesetze der Atmosphärischen Elektricität, Wien. Sitzber., Bd. XCIII, Abth. II, 1886, that useful observations on the normal electrical state of the atmosphere during the summer months are frequently rendered impossible by reason of the disturbances caused by dust particles in the air. The clouds of flying dust often change the normal potential of the air, which increases from the earth's surface upwards, to a negative potential, and even when this reversal of potential does not occur, must materially affect the amount of the positive increase. No such disturbances could be traced in the potentials observed at sea. They were invariably positive. Observations at sea are free also from any constant error, such as affects those made on land, due to irregularities in the configuration of the earth's surface and to the presence of buildings and trees. The effect due to the vessel can be determined by a special observation and allowed for in all subsequent work. It is only necessary to make simultaneous observations on the vessel and in a boat at some distance from it, to obtain data for reducing all potentials observed on the vessel to the true potentials at the sea level and referred to the earth's sphere. Hence, if we adopt Exner's view that the earth is negatively charged and that its charge is a cosmical constant which can be determined by observation of the rate of change of potential at the earth's surface, the data from which this charge can be most accurately calculated must be those obtained at sea. Observations at sea are also very well adapted to test the relation between the potential and the humidity of the atmosphere and offer exceptional facilities for the study of the effect of clouds.

The observations were made with a Thomson's portable electrometer, which was found to be much more sensitive and accurate than the portable gold-leaf electrometer used by Exner. The motion of the vessel did not interfere in any way with the accuracy of the readings. It was easy to repeat a setting of the attracting plate to within one division of the micrometer head. This insured an accuracy of measurement far greater than is necessary in this class of observations, in which so many unexplained fluctuations are constantly occurring. The instrument was charged

negatively by the use of a rubber electrophorus excited with gun cotton, so that a positive charge on the attracting plate made it necessary to raise it to bring the aluminium balance into the sighted position. A higher reading of the micrometer thus indicates a positive potential of the attracting plate. The constant of the instrument was determined in the physical laboratory of Princeton College by the use of a storage battery of 48 cells, of which the electromotive force was accurately known. It was taken as 2.5 volts for each division of the micrometer head.

The collector was constructed on the plan recommended by Exner. A short metal chimney was made, mounted on an ebonite rod. It held a candle, in the flame of which stood the end of a short copper wire, joined to the attracting plate of the electrometer, when desired, by a fine silk-covered copper wire. When an observation was made, this collector was held at heights above the deck of two, three, and four metres, and the respective settings of the micrometer were taken. Ground readings were made at the beginning and end of the set. It was found to be indifferent whether the ground contact was made by the finger of the observer or by a copper wire making connection with the water. The collector was held as far out over the rail as possible on the weather quarter of the vessel.

In the following table are collected the observations thus made and an approximate value of the rate of change of potential with the vertical height of the collector. This change is expressed in volts per metre and appears in the column headed $\frac{dv}{dn}$. It was always positive.

Date.	Time.	Potentials at—			
		2 metres.	3 metres.	4 metres.	$\frac{dv}{dn}$
Aug. 4	13 0	107	172	275	100
6	10 50	8	....	22	7
	16 0	60	....	110	25
7	9 10	85	107	135	28
	14 0	30	70	145	75
	15 20	47	102	162	60
	19 15	67	....	107	20
8	8 45	97	155	200	45
	13 20	120	130	142	12
18	11 30	50	70	97	27
	16 30	82	117	150	33
20	13 45	120	....	222	50
21	16 30	....	....	100	....
Sept. 4	13 45	92	130	150	20
5	10 0	62	....	112	25

The values of $\frac{dv}{dn}$ were taken, when practicable, from the potentials at the distances 3 and 4 metres above the deck, since it was thought that the disturbing effect of the vessel would be less for them than for those taken at the lower points.

In one or two cases there appeared to be no change of potential. This was believed to be due to defective insulation, and the observations are not included in the table. No negative potentials were observed.

In connection with the electrometer observations the readings of the dry and wet bulb thermometers were taken, and from them were obtained the relative humidity

and the weight in grammes of the water vapor in the air, or the actual humidity. The clouds and the state of the atmosphere were also recorded. The following table contains the rate of change of potential $\frac{dv}{dn}$, the temperature T in centigrade degrees, the relative humidity R. H., the water vapor W. in grammes, and the estimated clouds.

$\frac{dv}{dn}$	T.	R. H.	W.	Cloud.	
100	24.5	70.8	15.70	0	
7	19.7	84.2	14.15	4	
25	23.9	76.8	16.47	3	
28	20.3	83.5	14.57	2	
75	25.0	60.8	13.88	5	
60	25.0	56.2	12.83	2	
20	22.0	70.2	13.51	1	Clear overhead.
45	22.7	71.1	14.23	$\frac{1}{4}$	
12	21.6	71.2	13.40	......	Haze overhead.
27	21.8	74.2	14.11	......	Light stratus overhead.
33	22.1	75.7	14.66	......	Do.
50	23.4	90.3	18.71	......	Light stratus; clear overhead.
20	27.2	59.0	15.23	......	Light cirrus just forming.
25	24.4	91.1	20.12	4	Clear overhead.

In this table there does not appear any simple relation between the potential changes and the humidity. According to Exner the water vapor passes into the atmosphere negatively charged, and as it is present in greater or less amount the normal rate of rise of potential is more or less diminished. Arrhenius considers the free negative charges which lower the potential to reside on small dust or water particles floating in the air, which have become charged by electrolytic conduction through the air of electricity from the earth. To test between these views, a large number of observations should be made in fine cloudless weather. No conclusion in favor of either of them can be drawn from these observations. There seems to be a relation between the rise of potential and the clearness of the sky, although there are some marked exceptions to the rule that the clearer sky accompanies the greater rise of potential.

The observations here given were not reduced to the sea level by auxiliary measurements made at a distance from the vessel. The collector was held as far away as practicable from the sails and standing rigging. When the collector was held at a height of 4 metres and close to the mainsail there could not be detected any difference of potential between the collector and the ground. This is in accord with the experiments of Exner on the electrical state near buildings and high cliffs. The equipotential surface of zero potential passes over all bodies on the earth's surface, unless they are especially and carefully insulated. It is not unlikely that some of the inconsistencies noticed in the observations were due to the different positions of the mainsail at the times that they were taken. In future observations it would be advisable to use a water-dropper collector lashed in the main shrouds on the weather side of the vessel. If such a collector were fitted with a long dropping tube it would be practically independent of any ordinary changes in the vessel's trim.

REPORT UPON THE ZOOLOGICAL COLLECTIONS.

BY W. K. BROOKS, PH. D.,

Professor of Morphology, Johns Hopkins University.

The following surface animals were collected by the *Grampus:*

SALPA CABOTI.—More than 1,000 specimens each of the chain and solitary forms.

SALPA CLOTHO.—About 100 specimens of the chain and 20 of the solitary form.

SALPA, n. sp.—A few mutilated specimens of what seems to be a new species were brought up on the thermometer tubes.

SALPA, n. sp.—A single specimen of a species which has not yet been identified.

SALPA PINNATA.—One of the most remarkable results of the explorations made by the *Grampus* is the discovery of this species in great abundance along our coast. Two specimens were obtained in 1888 and more than 100 in 1889, and as it is a large and conspicuous species the fact that its occurrence in our waters has never been recorded is noteworthy. The collection contains great numbers of specimens of the chain form at all stages of development and four specimens of the solitary form with stolons.

The fact that this species is generally distinct from the ordinary *Salpa* has already been pointed out, and Herdman has proposed for it the generic name *Cyclosalpa.* My own study of its structure and development shows that it is a primitive type, midway between *Pyrosoma* and *Salpa*, and it is therefore peculiarly adapted for the intelligent study of the process of budding, upon the history and origin of which it gives most conclusive evidence.

Part 4 of vol. XXIII of the *Jenaische Zeitschrift* contains a most thorough and exhaustive memoir by Seeliger on the development of Pyrosoma (Zur Entwicklungsgeschichte der Pyrosomen, mit tafeln XXX–XXXVII), in which the author confirms, in all essential particulars, the accounts which Huxley and Kowalevsky have given us of the process of budding in Pyrosoma. Seeliger's account is much more minute and detailed than the older papers, and is a most valuable contribution to our knowledge of the subject, and in fact it appears to be so complete as to leave nothing more to be done, but it shows also that the older accounts were perfectly accurate, although they were less exhaustive than Seeliger's researches.

In a paper which I published in 1886, in vol. III of the "Studies from the Biological Laboratory of the Johns Hopkins University," on "The Anatomy and Development of the Salpa Chain," I showed that, after the secondary complications due to crowding and pressure are allowed for, the process of budding in Salpa is strictly comparable in every essential particular with that which had been described in Pyrosoma by Huxley and Kowalevsky; that "the Salpa chain is a single series of animals like the Pyrosoma stolon; the middle plane of the stolon the same as those of the Salpæ; that the right halves of all the bodies arise on the right half of the stolon, and their left halves on its left, and that they are not formed by budding from its walls but by the direct conversion of its tissues and cavities into those of the Salpa, and that the process is directly comparable, in every particular, with the published accounts of what occurs in Pyrosoma." (Page 472.)

My reason for publishing the paper was, as I then stated, the appearance of Seeliger's paper on the budding of Salpa (Die Knospung der Salpen, von Oswald Seeliger, *Jen. Zeitschrift*, XIX, 1885), and I showed that this author, like all the others

who had written on the subject, had gone hopelessly astray in the interpretation of his sections, and that his account of the process of budding in Salpa is of no more value than those given by earlier writers.

I am pleased to learn from his new memoir on Pyrosoma that Seeliger now holds the view which I have advocated, as to the essential similarity between the Salpa-stolon and that of Pyrosoma, but I am surprised to find that the only reference to my work on the subject is the statement that I have "emphasized" this resemblance:

> "Die Umbildung der einzelnen Segmente des Stolo (of Pyrosoma) zu einer vollständigen Pyrosoma verläuft, wie schon Brooks betonen konnte, sehr ähnlich mit den Vorgängen in der Salpen entwicklung." (Page 613.)

It seems to me that this is a very inadequate recognition of the fact that I pointed out the resemblance in detail, in contradiction of Seeliger's own statement of the case, and in opposition to all other published accounts.

During the last year I have been studying the Salpæ which were collected by the *Albatross*, and those collected by Professor Libbey on the *Grampus*, and as these collections furnish material for the comparative study of the process of budding, I have been able to amplify and complete my work on the subject, and to illustrate it by comparisons between different species. I am now preparing the illustrations for a memoir on the budding of Salpa, which will be ready for publication this fall. Two species, collected by the *Grampus*, are peculiarly favorable for studying the minute details of the process. One of them, which was brought up on the thermometer tubes of the *Grampus*, is very similar to if not identical with *S. pinnata* of the Mediterranean. It is not a true Salpa, as it differs from the ordinary species of this genus in many structural features. It is especially valuable for the study of the process of budding, as the Salpæ gradually increase in size from the base to the tip of the stolon, and it is therefore peculiarly valuable for studying the histology of the process of budding, and for tracing the development of the various organs.

A second species, also collected by the *Grampus* (*S. clotho*), is peculiarly favorable for studying the anatomy of the chain, since the secondary complications which are brought about by crowding are more easily intelligible than in any other species I have studied. This is due to the fact that the young Salpæ attain to a larger size and to more perfect development before crowding takes place than they do in other species.

The study of these two species and of Seeliger's beautiful figures of Pyrosoma show that the resemblance between Salpa and Pyrosoma is even more perfect and complete than I had supposed, as it extends to all the details of structure.

DOLIOLUM, n. sp.—Great quantities of young specimens of a species of *Doliolum* in the stage with a ventral stolon.

RHIZOPHYSA.—5 specimens of a *Rhizophysa* which is probably *R. gracilis* Fewkes.

SIPHONOPHORÆ.—A number of specimens of *Abyles*, *Diphyes*, and fragments of other Siphonophores.

PTEROPODA.—10 specimens of *Clio* (*Cresis*) *virgula*; 150 young specimens of the same; 16 of *Cavolina tridentata*, 1 of *Cymbuliopsis calceola*.

HETEROPODA.—200 specimens of *Atlanta*; 3 of *Firolidia desmaresti*; 1 of *Carinaria cymbium* with shell; 8 larvæ with coiled shells, possibly *Firolidia* larvæ.

MEDUSÆ.—*Pelagia cyanella*; *Margelis*, sp.

CTENOPHORÆ.—*Idyopsis*; *Beroe*, young.

About 30 young pelagic fishes.

RECORD OF SERIAL TEMPERATURES AND DENSITIES.

Station No. 1 (A 2). Lat. 41° 7′ 00″ N.; Long. 70° 00′ 00″ W. July 24, 1889, 8 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	61.9	61.9	6795	1.0248	61.0	1.02411	......
13	61.8	61.8	66737	1.0248	61.9	1.02424	7

Station No. 2 (A 3). Lat. 40° 56′ 00″ N.; Long. 70° 00′ 00″ W. July 24, 1889, 10 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	59.4	59.4	6795	1.0250	59.0	1.02406	......
14	57.3	57.2	66737	1.0254	59.0	1.02446	7

Station No. 3 (A 4). Lat. 40° 46′ 39″ N.; Long. 70° 00′ 00″ W. July 24, 1889, 12 m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	62.8	62.8	6795	1.0252	62.0	1.02465	......
24	50.0	49.2	66737	1.0262	58.8	1.02524	7

Station No. 4 (A 5). Lat. 40° 35′ 00″ N.; Long. 70° 00′ 00″ W. July 24, 1889, 2 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	66.9	66.9	6795	1.0249	66.0	1.02492	......
14	51.0	50.9	66661	......	......	......	......
24	47.0	46.7	52728	......	......	......	......
34	46.3	46.2	66737	1.0264	57.0	1.02522	6

Station No. 5 (A 6). Lat. 40° 24′ 00″ N.; Long. 70° 00′ 00″ W. July 24, 1889, 5 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	67.5	67.5	6795	1.0251	67.5	1.02534	......
9	65.5	65.4	66724	......	......	......	......
14	52.0	51.8	66731	......	......	......	......
19	48.5	48.4	66664	......	......	......	......
24	46.1	46.0	62365	......	......	......	......
29	45.6	45.2	63911	......	......	......	......
34	45.2	45.1	66737	......	......	......	......
39	46.0	45.7	52728	......	......	......	......
44	45.3	45.2	66661	1.0263	56.3	1.02504	7

Station No. 6 (A 7). Lat. 40° 13′ 00″ N.; Long. 70° 2′ 00″ W. July 24, 1889, 7 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	66.8	66.8	6795	1.0249	66.0	1.02492	......
10	65.0	64.8	66659	......	......	......	......
15	67.0	66.7	*66665	......	......	......	......
20	64.3	64.2	66661	......	......	......	......
25	64.9	64.5	52728	......	......	......	......
30	45.7	45.6	66737	......	......	......	......
35	45.2	44.8	63911	......	......	......	......
40	45.8	45.6	66663	......	......	......	......
45	50.2	50.0	66731	......	......	......	......
50	45.4	45.3	66664	......	......	......	......
54	44.0	44.1	66724	1.0265	55.0	1.02709	6

Station No. 7 (A 8). Lat. 40° 2′ 00″ N.; Long. 70° 3′ 00″ W. July 24, 1889, 9 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	66.5	66.5	6795	......	......	......	......
10	66.0	65.9	66731	......	......	......	......
15	66.0	66.1	62365	......	......	......	......
20	48.8	48.7	63911	......	......	......	......
30	47.0	46.9	66737	......	......	......	......
40	46.0	45.7	52728	......	......	......	......
50	46.8	46.7	66661	......	......	......	......
60	48.0	47.8	66665	......	......	......	......
70	47.7	47.4	66659	1.0278	57.0	1.02662	6

Station No. 8 (A 9). Lat. 39° 51′ 00″ N.; Long. 70° 4′ 00″ W. July 24, 1889, 11 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	68.2	68.2	6795	1.0249	68.0	1.02522	......
25	56.0	55.8	66661	......	......	......	......
50	52.0	51.7	52728	......	......	......	......
75	53.8	53.6	66737	......	......	......	......
125	48.0	47.6	63911	......	......	......	......
175	43.0	42.9	62365	......	......	......	......
225	41.8	41.7	66731	......	......	......	......
230	......	......	......	1.0262	62.8	1.02576	6

Station No. 9 (A 10). Lat. 39° 40′ 00″ N.; Long. 70° 6′ 00″ W. July 25, 1889, 1 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	69.0	69.0	6795	......	......	......	......
25	56.0	56.0	62365	......	......	......	......
50	55.4	55.3	63911	......	......	......	......
75	52.4	52.2	66737	......	......	......	......
175	45.0	44.7	52728	......	......	......	......
275	41.2	41.1	66661	......	......	......	......
950	......	......	6795	1.0286	58.0	1.02754	6

Station No. 10 (B 12). Lat. 39° 27′ 00″ N.; Long. 70° 9′ 00″ W. July 25, 1889, 1 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.6	72.6	6795	1.0245	72.6	1.02554	......
10	72.5	72.6	66726	......	......	......	......
25	69.5	69.4	66724	......	......	......	......
50	54.0	54.0	66664	......	......	......	......
75	54.0	53.7	66659	......	......	......	......
100	52.2	52.0	66665	......	......	......	......
150	48.0	47.8	66731	......	......	......	......
200	45.1	45.0	66661	......	......	......	......
250	47.6	47.3	52728	......	......	......	......
300	44.4	44.3	66737	......	......	......	......
400	43.9	43.5	63911	......	......	......	......
500	40.0	39.9	62365	1.0282	63.5	1.02786	6

Station No. 11 (C 11). Lat. 39° 34′ 00″ N.; Long. 70° 21′ 00″ W. July 25, 1889, 4 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	71.3	71.3	6795	1.0258	71.0	1.02659	......
15	71.3	71.4	66726	......	......	......	......
30	55.8	55.8	66724	......	......	......	......
50	55.8	55.8	66664	......	......	......	......
75	53.7	53.4	66659	......	......	......	......
100	53.7	53.5	66731	......	......	......	......
150	48.7	48.5	66661	......	......	......	......
200	46.8	46.5	52728	......	......	......	......
250	45.6	45.5	66737	......	......	......	......
300	45.5	45.4	63911	......	......	......	......
400	39.8	39.7	62365	1.0288	62.0	1.02825	6

Station No. 12 (C 10). Lat. 39° 44′ 00″ N.; Long. 70° 21′ 00″ W. July 25, 1889, 6 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	70.2	70.2	6795	1.0260	70.0	1.02663	......
15	65.0	64.9	66726	......	......	......	......
30	52.4	52.4	66724	......	......	......	......
50	53.5	53.5	66664	......	......	......	......
75	54.3	54.0	66659	......	......	......	......
100	52.4	52.2	66731	......	......	......	......
150	47.3	47.2	66661	......	......	......	......
200	45.8	45.5	52728	......	......	......	......
250	41.6	41.5	66737	......	......	......	......
300	44.2	43.8	63911	......	......	......	......
400	39.8	39.7	62365	1.0282	56.2	1.02692	6

* Thermometer did not reverse.

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 13 (C 9). Lat. 39° 54′ 00″ N.; Long. 70° 21′ 00″ W. July 25, 1889, 11 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	69.0	69.0	6795				
25			*66664				
50	53.0	52.7	66659				
75	50.5	50.3	66731				
100	49.1	49.0	66661				
150	46.0	45.7	52728				
200	42.0	41.9	66737				
250	41.5	41.1	63911				
300	39.8	39.7	62365	1.0282	55.0	1.02679	6

Station No. 14 (C 8). Lat. 40° 4′ 00″ N.; Long. 70° 21′ 00″ W. July 26, 1889, 6 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	64.8	64.8	6795	1.0254	64.0	1.02513	
5			*66724				
10	58.4	58.4	66664				
20	46.3	46.0	66659				
30	45.0	44.9	66731				
40	46.0	45.9	66661				
45	47.4	47.1	52728				
50	49.0	48.9	66737				
60	49.7	49.3	63911				
70	48.4	48.4	62365				
76	45.4	45.3	66726	1.0280	59.2	1.02708	6

Station No. 15 (C 7). Lat. 40° 14′ 00″ N.; Long. 70° 21′ 00″ W. July 26, 1889, 9 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.0	67.0	6795	1.0251	67.0	1.02527	
10	57.0	56.9	66731				
15	51.3	51.1	66661				
20	47.4	47.1	52728				
30	45.7	45.6	66737				
40	45.6	45.2	63911				
50	42.6	42.5	62365	1.0268	55.0	1.02539	6

Station No. 16 (C 6). Lat. 40° 24′ 11″ N.; Long. 70° 21′ 00″ W. July 26, 1889, 11 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	68.0	68.0	6795	1.0250	68.0	1.02532	
8	60.0	59.6	52728				
13	49.2	49.0	66737				
23	49.1	49.0	63911				
34	46.2	46.2	62365				
37			5320	1.0266	56.5	1.02536	6

Station No. 17 (C 5). Lat. 40° 34′ 00″ N.; Long. 70° 21′ 00″ W. July 26, 1889, 1 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	68.5	68.5	6795	1.0252	68.5	1.02559	
8	62.2	62.1	66661				
13	55.4	55.0	52728				
18	53.0	52.8	66737				
23	54.6	54.5	63911				
28			5320	1.0270	56.5	1.02576	6

Station No. 18 (C 4). Lat 40° 44′ 00″ N.; Long. 70° 21′ 00″ W. July 26, 1889, 3 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	68.0	68.0	6795	1.0249	68.0	1.02522	
4	67.9	67.8	66661				
9	53.6	53.2	52728				
14	50.7	50.5	66737				
19			*63911				
24	50.6	50.6	62365				
25			5320	1.0267	56.8	1.02550	6

Station No. 19 (C 3). Lat. 40° 54′ 00″ N.; Long. 70° 21′ 00″ W. July 26, 1889, 5 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	65.4	65.4	6795	1.0250	65.0	1.02487	
5	62.3	62.3	66737				
10	53.8	53.4	52728				
15	52.3	52.1	66661				
20			*63914				
22			5320	1.0280	56.6	1.02677	6

Station No. 20 (C 2). Lat. 41° 4′ 00″ N.; Long. 70° 21′ 00″ W. July 26, 1889, 7 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	65.5	65.5	6795	1.0250	65.0	1.02487	
5	64.0	63.9	66661				
10	56.7	56.3	52728				
15	63.3	63.3	66737				
18			5320	1.0260	59.7	1.02514	6

Station No. 21 (F 1). Lat. 41° 12′ 00″ N.; Long. 70° 50′ 00″ W. August 1, 1889, 8 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.4	67.4	6795	1.0244	67.0	1.02457	
8	62.0	61.6	52728				
13	60.0	59.9	66661	1.0256	65.0	1.02547	6

Station No. 22 (F 2). Lat. 41° 2′ 00″ N.; Long. 70° 50′ 00″ W. August 1, 1889, 12 m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	69.8	69.8	6795	1.0248	69.6	1.02536	
5	66.2	66.2	63914				
10	60.9	60.8	66661				
15	50.0	49.8	66737				
20	50.0	49.6	52728				
21			5320	1.0256	60.9	1.02488	6

Station No. 23 (F 3). Lat. 40° 52′ 00″ N.; Long. 70° 50′ 00″ W. August 1, 1889, 3 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	71.8	71.8	6795	1.0247	71.5	1.02556	
5	68.2	68.2	*62365				
10	68.0	68.0	*63914				
15	49.5	49.3	66661				
20	48.7	48.5	66737				
29	47.0	46.6	52728	1.0258	62.0	1.02525	6

Station No. 24 (F 4). Lat. 40° 42′ 00″ N.; Long. 70° 50′ 00″ W. August 1, 1889, 6 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	73.2	73.2	6795	1.0242	73.0	1.02530	
5	72.0	72.0	66731				
10	70.7	70.7	62365				
15	63.7	63.7	63914				
20	64.0	63.9	66661				
25	47.6	47.4	66737				
34	46.3	45.9	52728	1.0264	59.6	1.02553	6

Station No. 25 (F 5). Lat. 40° 32′ 00″ N.; Long. 70° 50′ 00″ W. August 1, 1889, 9 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	72.8	72.8	6795	1.0242	72.6	1.02524	
10	71.6	71.6	66731				
15	71.0	71.0	62365				
20	49.2	49.3	63914				
25	62.0	61.9	66661				
30	48.7	48.5	66737				
37	50.5	50.1	52728				
38				(†)			6

* Thermometer did not reverse.

† No water.

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 26 (F 6). Lat. 40° 22′ 00″ N.; Long. 70° 50′ 00″ W. August 2, 1889, 1 a. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	72.3	72.3	6795	1.0241	72.0	1.02504	
10	70.5	70.5	62365				
15	69.4	69.4	63914				
25	70.0	69.9	66661				
35	60.5	60.5	66737				
43	46.0	45.6	52728	1.0264	60.2	1.02560	6

Station No. 27 (F 7). Lat. 40° 12′ 00″ N.; Long. 70° 50′ 00″ W. August 2, 1889, 4 a. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	72.0	72.0	6795	1.0243	72.0	1.02524	
10	69.2	69.2	62365				
20	55.0	55.0	63916				
30	54.0	53.8	66661				
40	47.2	47.0	66737				
55	46.8	46.4	52728	1.0268	58.0	1.02574	6

Station No. 28 (G 1). Lat. 41° 12′ 00″ N.; Long. 71° 00′ 00″ W. August 2, 1889, 12 m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	70.5	70.5	6795	1.0248	70.2	1.02546	
5	68.1	68.0	66661				
10	58.6	58.6	63914				
18	53.5	53.5	62365				
19			5320	1.0258	60.4	1.02503	6

Station No. 29 (H 1). Lat. 41° 12′ 00″ N.; Long. 71° 10′ 00″ W. August 2, 1889, 2 p. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	71.6	71.6	6795	1.0246	71.5	1.02546	
5	68.4	68.4	66737				
10	58.6	58.5	66661				
15	54.0	54.1	63914				
19	51.5	51.5	62365				
20			5320	1.0254	61.5	1.02478	6

Station No. 30 (J 1). Lat. 41° 12′ 00″ N.; Long. 71° 20′ 00″ W. August 2, 1889, 4 p. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	72.7	72.7	6795	1.0238	72.6	1.02484	
5	70.4	70.2	52728				
10	61.9	61.8	66661				
15	52.9	53.0	63914				
20	49.3	49.3	62365				
22			5320	1.0252	56.2	1.02392	6

Station No. 31 (K 1). Lat. 41° 12′ 00″ N.; Long. 71° 30′ 00″ W. August 2, 1889, 6 p. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	68.6	68.6	*6795	1.0240	68.5	1.02439	
5	68.0	67.9	66661				
10	66.1	66.1	63914				
17	50.4	50.4	62365				
18			5320	1.0252	58.2	1.02416	6

Station No. 32 (K 2). Lat. 41° 2′ 00″ N.; Long. 71° 30′ 00″ W. August 4, 1889, 8 a. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	67.8	67.8	6795	1.0240	67.8	1.02429	
5	62.1	61.7	52728				
10	52.0	51.8	66661				
15	65.0	60.5	*63914				
22	52.4	52.4	*62365				
23			5320	1.0263	55.7	1.02497	6

Station No. 33 (J 2). Lat. 41° 2′ 00″ N.; Long. 71° 20′ 00″ W. August 4, 1889, 10 a. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	70.7	70.7	6795	1.0238	70.5	1.02451	
5	59.2	58.8	52728				
10	50.1	49.9	66661				
15	49.3	49.4	63914				
24	46.3	46.2	62365				
25			5320	1.0261	55.5	1.02474	6

Station No. 34 (H 2). Lat. 41° 00′ 00″ N.; Long. 71° 10′ 00″ W. August 4, 1889, 12 m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	72.3	72.3	6795	1.0240	72.0	1.02494	
5	67.8	67.8	66731				
10	53.0	52.6	52728				
15	50.0	49.8	66661				
20	46.6	46.7	63914				
25	46.4	46.4	62365				
26			5320	1.0259	58.4	1.02489	6

Station No. 35 (G 2). Lat. 41° 2′ 00″ N.; Long. 71° 00′ 00″ W. August 4, 1889, 2 p. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	71.3	71.3	6795	1.0242	71.3	1.02503	
5	67.5	67.1	52728				
10	52.2	51.8	52728				
15	50.1	50.1	62365				
21	48.0	48.0	62365				
22			5320	1.0258	58.7	1.02482	6

Station No. 36 (E 1). Lat. 41° 12′ 00″ N.; Long. 70° 40′ 00″ W. August 4, 1889, 6 p. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	69.3	69.3	6795	1.0244	69.1	1.02488	
5	68.0	68.0	63914				
11	59.0	58.6	52728				
17	57.9	58.0	62365				
18			5320	1.0254	61.3	1.02475	6

Station No. 37 (E 2). Lat. 41° 2′ 00″ N.; Long. 70° 40′ 00″ W. August 4, 1889, 8 p. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	67.6	67.6	6795	1.0250	69.0	1.02547	
5			*66656				
10	53.4	53.2	66731				
15	48.0	47.8	66661				
20	47.0	47.1	63914				
25	47.0	46.6	52728				
26			5320	1.0262	56.5	1.02496	6

Station No. 38 (E 3). Lat. 40° 52′ 00″ N.; Long. 70° 40′ 00″ W. August 4, 1889, 11 p. m.

Depth (fath.)	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Surface	70.0	70.0	6795	1.0240	71.2	1.02482	
5	70.0	69.8	*66664				
10	58.2	58.1	66731				
15	48.3	48.4	63914				
20	58.7	58.6	66661				
31	51.5	51.1	52728				
32			5320	1.0263	55.0	1.02489	6

* Thermometer did not reverse.

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Station No. 39 (E 4). Lat. 40° 42′ 00″ N.; Long. 70° 40′ 00″ W. August 5, 1889, 4 a. m.							
Surface	71.4	71.4	6795	1.0240	73.0	1.02510	
5	71.8	71.7	66659				
10	71.0	71.0	66737				
15	70.5	70.3	66664				
20	49.0	48.8	66731				
25	46.7	46.8	63914				
30	46.2	46.0	66661				
34	45.9	45.5	52728				
35			5320	1.0254	64.0	1.02513	6
Station No. 40 (E 5). Lat. 40° 32′ 00″ N.; Long. 70° 40′ 00″ W. August 5, 1889, 8 a. m.							
Surface	72.3	72.3	6795	1.0241	73.4	1.02527	
5	72.7	72.6	66659				
10	65.8	65.8	66737				
15	49.7	49.5	66731				
20	47.8	47.9	63914				
25	46.1	45.9	66661				
30	46.0	45.6	52728				
39	45.0	44.9	66664				
40			5320	1.0280	56.7	1.02678	6
Station No. 41 (F 5). Lat. 40° 31′ 00″ N.; Long. 70° 50′ 00′ W. August 5, 1889, 10 a. m.							
Surface	72.2	72.2	6795	1.0240	73.6	1.02520	
5	72.3	72.2	66659				
10	72.2	72.2	66731				
15	57.3	57.4	63914				
20	49.0	48.8	66661				
25	58.5	58.1	52728				
30	46.0	45.9	66664				
40	44.9	44.8	66737				
43			5320	1.0270	59.5	1.02612	6
Station No. 42 (G 3). Lat. 40° 52′ 00″ N.; Long. 71° 00′ 00″ W. August 5, 1889, 4 p. m.							
Surface	69.4	69.4	6795	1.0240	70.6	1.02472	
5	69 2	69.2	66731				
10	67.8	67.8	63914				
15	48.1	47.9	66661				
20	46.0	45.6	52728				
25	45.0	44.9	66664				
31			*66737				
32			5320	1.0260	58.4	1.02499	6
Station No. 43 (D 1). Lat. 41° 12′ 00″ N.; Long. 70° 30′ 00″ W. August 6, 1889, 6 p. m.							
Surface	71.0	71.0	6795	1.0241	71.2	1.02492	
5	69.0	68.8	52728				
10	66.9	66.9	66737				
15	53.0	53.0	66664				
22	51.5	51.3	66656				
22			5320	1.0258	58.4	1.02479	6
Station No. 44 (D 2). Lat. 41° 2′ 00″ N.; Long. 70° 30′ 00″ W. August 7, 1889, 9 a. m.							
Surface	71.2	71.2	6795	1.0240	71.8	1.02491	
5	70.5	70.2	66656				
10	52.7	52.5	66661				
15	48.9	48.6	52728				
20	48.0	47.8	66737				
25	48.0	48.0	66664				
26			5320	1.0264	55.8	1.02508	6
Station No. 45 (D 3). Lat. 40° 51′ 47″ N.; Long. 70° 30′ 00″ W. August 7, 1889, 1 p. m.							
Surface	74.6	74.6	6795	1.0234	76.8	1.02516	
5	71.4	71.1	66656				
10	61.1	61.0	66664				
15	67.8	67.7	66737				
20	48.0	47.7	52728				
27	47.4	47.2	66661				
28			5320	1.0280	57.6	1.02689	6
Station No. 46 (D 4). Lat. 40° 42′ 00″ N.; Long. 70° 30′ 00″ W. August 7, 1889, 4 p. m.							
Surface	73.6	73.6	6795	1.0238	75.6	1.02534	
5	72.0	71.7	66656				
10	62.2	62.2	63914				
15	51.1	50.9	66661				
20	49.0	48.7	52728				
25	46.8	46.6	66737				
31	47.0	46.9	66664				
32			5320	1.0264	56.6	1.02517	6
Station No. 47 (D 5). Lat. 40° 32′ 00″ N.; Long. 70° 30′ 00″ W. August 7, 1889, 7 p. m.							
Surface	72.6	72.6	6795	1.0238	74.2	1.02510	
5	71.7	71.4	66656				
10	58.3	58.2	66664				
15	50.3	50.1	66737				
20	49.6	49.3	52728				
25	47.5	47.3	66661				
33	46.2	46.3	63914				
34			5320	1.0268	56.4	1.02555	6
Station No. 48 (D 6). Lat. 40° 22′ 00″ N.; Long. 70° 30′ 00″ W. August 7, 1889, 9 p. m.							
Surface	71.5	71.5	6795	1.0240	72.0	1.02494	
5	71.7	71.4	66656				
10	69.3	69.2	66731				
15	69.0	69.0	63914				
20	47.0	46.8	66661				
25	46.5	46.2	52728				
30	46.0	45.8	66737				
40	45.0	44.9	66664				
41			5320	1.0274	55.0	1.01599	6
Station No. 49 (D 7). Lat. 40° 12′ 00″ N.; Long. 70° 30′ 00″ W. August 7, 1889, 11 p. m.							
Surface	70.0	70.0	6795	1.0245	70.8	1.02525	
4	70.2	69.9	66656				
9	69.7	69.6	66659				
14	55.3	55.1	66661				
19	47.5	47.3	66737				
24	47.2	46.9	52728				
29	47.0	46.9	66661				
39	46 7	46.8	63914				
54	47.0	46.8	66731				
55			5320	1.0276	56.5	1.02636	6

* Thermometer did not reverse.

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 50 (D 8). Lat. 40° 2′ 00″ N.; Long. 70° 30′ 00″ W. August 8, 1889, 7 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	70.3	70.3	6795	1.0246	72.2	1.02558	
5	70.4	70.1	66656				
10	70.1	70.1	63920				
15	69.1	69.2	63921				
20	63.8	63.7	66663				
25	60.4	60.5	62365				
30	55.0	54.9	66665				
40	54.3	54.1	66726				
50	51.0	51.0	66724				
60	53.2	53.0	66661				
70	55.0	55.1	63914				
80	52.7	52.5	66731				
90	51.1	50.8	52728				
100	48.4	48.6	66737				
125	47.0	47.0	66664				
150	45.0	44.7	66659	1.0283	53.2	1.02671	6

Station No. 51 (D 10). Lat. 39° 49′ 00″ N.; Long. 70° 30′ 00″ W. August 8, 1889, 9 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.9	72.9	6795	1.0246	74.8	1.62601	
5	72.2	72.1	66661				
10	72.1	72.1	63914				
15	60.0	59.9	66731				
20	58.2	57.8	52728				
25	54.5	54.3	66737				
35	58.0	57.9	66664				
50	57.8	57.8	66731				
75	50.0	49.7	66659				
100	57.5	57.1	52728				
150	44.5	44.4	66737				
250	41.1	41.0	66664				
350	39.8	39.5	66659	1.0280	54.6	1.02654	6

Station No. 52 (D 10). Lat. 39° 42′ 00″ N.; Long. 70° 30″ 00″ W. August 8, 1889, 3 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.2	72.2	6795	1.0250	73.7	1.02622	
5	72.0	71.7	66656				
10	71.0	71.1	66726				
15	62.0	61.7	66665				
20	48.0	48.0	62365				
25	50.1	50.0	66663				
30	51.0	50.9	63921				
40	51.1	51.0	63920				
50	54.0	53.8	66658				
75	53.5	53.2	66659				
100	49.9	49.9	66664	1.0280	62.8	1.02756	8
150	46.1	46.0	66737				
200	43.1	42.8	52728				
300	40.8	40.7	66731				
400	39.9	40.0	63914				
500	39.2	39.1	66661	1.0281	60.6	1.02736	6

Station No. 53 (D 11). Lat. 39° 32′ 00″ N.; Long. 70° 30′ 00″ W. August 8, 1889, 11 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	71.4	71.4	6795	1.0245	72.2	1.02548	
5	72.0	71.7	66656				
10	70.6	70.5	66659				
15	66.0	65.9	66664				
20	65.3	65.2	66726				
25	66.8	66.5	66665				
30	58.8	58.8	66737				
40	55.8	55.6	66661				
50	54.0	54.1	63914				
75	53.8	53.6	66731				
100	51.2	50.8	52728	1.0276	64.2	1.02736	6
150	48.0	47.6	52728				
200	45.2	45.1	66731				
250	42.0	42.1	63914				
300	40.6	40.5	66661				
400	39.8	39.6	66665				
500	39.2	39.1	66726	1.0279	60.0	1.02708	6

Station No. 54 (D 12). Lat. 39° 22′ 00″ N.; Long. 70° 30′ 00″ W. August 9, 1889, 3 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	71.9	71.9	6795	1.0250	72.6	1.02598	
5	72.1	71.8	66656				
10	72.1	72.1	62365				
15	64.6	64.5	66724				
20	63.0	62.9	66726				
25	51.3	51.1	66665				
30	51.0	50.8	66737				
40	54.1	53.9	66661				
50	53.9	54.0	63914				
75	52.9	52.7	66731				
100	51.9	51.6	52728	1.0278	63.6	1.02747	6
150	49.4	49.2	66665				
200	45.4	45.3	66737				
250	43.1	43.0	66661				
300	42.0	42.1	63914				
400	40.0	39.9	66731				
500	39.9	39.6	52728	1.0280	59.8	1.02715	6

Station No. 55 (D 13). Lat. 39° 12′ 00″ N.; Long. 70° 32′ 00″ W. August 9, 1889, 8 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	71.8	71.8	6795	1.0247	73.5	1.02588	
5	71.9	71.6	66656				
10	67.0	67.1	62365				
15	61.0	60.6	52728				
20	56.1	56.1	66724				
25	58.0	57.9	66726				
30	55.0	54.8	66665				
40	54.7	54.5	66737				
50	55.4	55.2	66661				
75	54.2	54.3	63914				
100	50.6	50.4	66731	1.0282	60.3	1.02742	6
150	47.9	47.7	66726				
200	45.2	45.0	66665				
250	42.9	42.8	66737				
300	41.3	41.2	66661				
400	39.9	40.0	63914				
500	39.4	39.3	66731	1.0283	57.2	1.02714	6

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 56 (E 13). Lat. 39° 14′ 00″ N.; Long. 70° 40′ 00″ W. August 9, 1889, 11 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	73.6	73.6	6795	1.0249	75.9	1.02650	
5	74.0	73.7	66656				
10	73.6	73.6	62365				
15	70.2	70.0	52728				
20	67.0	66.7	66665				
25	61.9	61.9	66737				
30	53.3	53.1	66661				
40	55.3	55.4	63914				
50	56.0	55.9	66731				
75	53.9	53.9	66724				
100	51.9	51.7	66726	1.0278	63.2	1.02742	6
150	50.0	49.8	66665				
200	46.9	46.8	66737				
250	44.4	43.3	66661				
300	42.1	42.2	63914				
400	40.2	40.1	66731				
500	39.3	39.4	66724	1.0277	60.6	1.02696	6

Station No. 57 (E 12). Lat. 39° 24′ 00″ N.; Long. 70° 40′ 00″ W. August 9, 1889, 1 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	72.8	72.8	6795	1.0245	74.8	1.02591	
5	75.1	75.8	66656				
10	73.2	73.2	62365				
15	63.2	62.9	66665				
20	57.3	56.9	52728				
25	51.0	50.8	66737				
30	51.0	50.8	66661				
40	51.8	51.9	63914				
50	53.0	52.8	66731				
75	54.1	54.1	66724				
100	52.2	52.0	66726	1.0275	64.3	1.02727	6
150	50.5	50.3	66737				
200	45.8	45.7	66661				
250	45.4	45.5	63914				
300	42.0	41.9	66731				
400	40.6	40.7	66724				
500	39.3	39.2	66726	1.0276	61.8	1.02702	6

Station No. 58 (E 11). Lat. 39° 34′ 00″ N.; Long. 70° 40′ 00″ W. August 9, 1889, 4 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	72.6	72.6	6795	1.0244	74.4	1.02574	
5	74.9	74.6	66656				
10	72.3	72.2	66659				
15	68.6	68.4	66664				
20	64.0	63.6	52728				
25	57.1	57.1	66737				
30	54.2	54.0	66661				
40	52.8	52.9	63914				
50	54.1	53.9	66731				
75	53.5	53.5	66724				
100	51.2	51.0	66726	1.0278	64.0	1.02753	6
150	49.1	49.2	63914				
200	45.0	44.9	66731				
250	41.2	41.3	66724				
300	40.4	40.3	66726	1.0278	59.3	1.02689	6

Station No. 59 (G 2). Lat. 41° 02′ 00″ N.; Long. 71° 00′ 00″ W. August 17, 1889, 12 m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	68.2	68.2	6795	1.0243	70.0	1.02493	
5	69.5	69.2	66656				
10	50.0	49.8	66731				
17	49.6	49.6	66724				
18			5320	1.0273	57.0	1.02612	6

Station No. 60 (G 3). Lat. 40° 52′ 00″ N.; Long. 71° 00′ 00″ W. August 17, 1889, 2 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	69.3	69.3	6795	1.0243	71.4	1.02515	
5	69.0	68.7	66656				
10	57.5	57.4	66661				
15	48.2	48.3	63914				
20	47.0	47.0	66724				
29			5320	1.0273	57.3	1.02616	6

Station No. 61 (G 4). Lat. 40° 42′ 00″ N.; Long. 71° 3′ 00″ W. August 17, 1889, 4 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	70.4	70.4	6795	1.0240	72.0	1.02494	
5	70.5	70.2	66656				
10	70.1	70.1	66737				
15	52.2	52.0	66731				
20	48.0	48.0	66724				
25	45.3	45.4	63914				
31	45.5	45.4	66661	1.0280	54.6	1.02655	6

Station No. 62 (G 5). Lat. 40° 32′ 00″ N.; Long. 71° 00′ 00″ W. August 17, 1889, 6 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	71.2	71.2	6795	1.0241	72.7	1.02516	
5	71.2	70.9	66656				
10	63.2	62.8	52728				
15	51.1	50.9	66661				
20	47.7	47.8	63914				
25	46.5	46.6	66724				
30	46.0	45.9	66731				
38	45.0	44.9	66737	1.0277	54.2	1.02621	6

Station No. 63 (G 6). Lat. 40° 22′ 00″ N.; Long. 71° 00′ 00″ W. August 17, 1889, 8 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	70.2	70.2	6812	1.0244	71.8	1.02531	
5	71.0	70.7	66656				
10	70.6	70.4	*66664				
15	58.3	58.3	63914				
20	48.8	48.6	66661				
25	59.7	59.6	66731				
30	48.0	48.1	63914				
40	46.7	46.6	66661				
48	45.7	45.4	52728	1.0281	54.4	1.02663	6

Station No. 64 (G 7.) Lat. 40° 12′ 00″ N.; Long. 71° 00′ 00″ W. August 17, 1889, 10 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	70.0	70.0	6812	1.0242	70.8	1.02495	
5	69.8	69.5	66658				
10	69.0	68.7	66656				
15	66.0	65.9	66726				
20	54.0	53.7	66659				
25	50.5	50.5	66664				
30	46.7	46.6	66731				
40	46.5	46.4	66737				
50	47.2	47.3	66724				
60	46.8	46.9	63914				
67	44.5	44.4	66661	1.0282	67.0	1.02637	6

* Thermometer did not reverse.

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 65 (G 8). Lat. 40° 2′ 00″ N.; Long. 71° 00′ 00″ W. August 17, 1889, 12 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	70.0	70.0	6812	1.0242	71.0	1.02499	
5	70.9	70.8	66663				
10	70.9	70.6	66665				
15	70.6	70.6	62365				
20	55.0	54.7	66659				
25	50.1	50.1	66664				
30	46.7	46.8	66724				
40	49.5	49.3	66737				
50	52.0	52.0	66724				
75	53.7	53.8	63914				
90	51.2	51.0	66661	1.0284	60.4	1.02730	6

Station No. 66 (G 9). Lat. 39° 52′ 00″ N.; Long. 71° 00′ 00″ W. August 18, 1889, 3 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	70.4	70.4	6812	1.0250	71.3	1.02583	
5	70.2	70.2	66731				
10	62.4	62.3	66726				
15	50.1	49.8	66659				
20	45.0	45.1	66724				
25	45.2	45.1	66664				
30	48.0	47.8	66661				
40	48.9	49.0	63914				
50	51.0	50.8	66737				
75	53.6	53.3	52728				
100	51.0	51.0	66664	1.0279	61.3	1.02725	6
150	46.0	45.9	66661				
200	43.8	43.9	63914				
250	41.0	40.9	66737				
300	39.9	39.8	66731				
335			5320	1.0290	56.2	1.02772	6

Station No. 67 (F 10). Lat. 39° 42′ 00″ N.; Long. 70° 54′ 00″ W. August 18, 1889, 8 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	71.3	71.3	6812	1.0247	72.5	1.02572	
5	70.6	70.7	66726				
10	64.7	64.6	66656				
15	49.3	49.1	66731				
20	47.0	47.0	66664				
25	46.0	46.8	66665				
30	47.8	47.6	66737				
40	50.2	50.3	63914				
50	52.1	51.9	66661				
75	53.7	53.7	66724				
100	50.3	50.0	66659	1.0281	62.7	1.02765	6
150	46.7	46.4	66659				
200	43.9	44.0	66724				
250	41.7	41.6	66661				
300	40.4	40.5	63914				
400	39.6	39.5	66737				
500	39.4	39.2	66665	1.0282	58.0	1.02714	6

Station No. 68 (F 11). Lat. 39° 30′ 00″ N.; Long. 70° 58′ 00″ W. August 18, 1889, 12 m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	73.2	73.2	6812	1.0244	74.3	1.02572	
5	72.1	71.8	66656				
10	71.9	71.8	66663				
15	56.5	56.5	62365				
20	50.9	50.9	66664				
25	46.5	46.3	66665				
30	48.0	47.8	66737				
40	48.1	48.2	63914				
50	54.8	54.6	66661				
75	54.6	54.6	66724				
100	50.4	50.1	66659	1.0275	66.7	1.02762	6
150	47.0	46.9	66737				
200	45.5	45.6	63914				
300	40.6	40.5	66661				
400	39.3	39.4	66724				
500	39.2	38.9	66659	1.0280	58.4	1.02699	6

Station No. 69 (G 12). Lat. 39° 22′ 00″ N.; Long. 71° 4′ 00″ W. August 18, 1889, 4 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	73.2	73.2	6812	1.0243	74.8	1.02571	
5	71.3	71.0	66656				
10	64.8	64.7	66724				
15	58.0	57.8	66659				
20	51.5	51.4	66663				
25	51.0	50.8	66661				
30	50.9	51.0	63914				
40	53.0	52.8	66737				
50	54.4	54.2	66665				
75	53.5	53.5	66664				
100	50.0	50.0	62365	1.0274	62.8	1.02696	6
150	45.3	45.4	63914				
200	43.3	43.2	66737				
250	41.9	41.7	66665				
300	40.8	40.7	66664				
400	39.6	39.5	62365				
500	39.2	39.1	66663	1.0283	61.3	1.02765	6

Station No. 70 (H 13). Lat. 39° 12′ 00″ N.; Long. 71° 9′ 30″ W. August 18, 1889, 8 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.4	72.4	6812	1.0242	71.5	1.02506	
5	72.4	72.1	66656				
10	71.1	71.0	66661				
15	58.0	57.9	66724				
20	47.1	47.0	66663				
25	46.0	45.7	66659				
30	46.0	46.1	63914				
40	48.4	48.2	66737				
50	52.0	51.8	66665				
75	53.7	53.7	66664				
100	51.1	51.1	62365	1.0274	64.3	1.02717	6
150	44.6	44.5	62365				
200	43.7	43.6	66664				
250	40.6	40.4	66665				
300	39.9	39.8	66737				
400	39.6	39.7	63914				
500	39.2	39.0	66656	1.0280	58.8	1.02704	6

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Cup No.
Station No. 71 (J 13). Lat. 39° 12′ 00″ N.; Long. 71° 20′ 00″ W. August 19, 1889, 4 a. m.							
Surface	71.0	71.0	6812	1.0246	71.7	1.02550	
5	71.7	71.4	66656				
10	62.0	61.9	66724				
15	55.2	55.0	66661				
20	49.9	49.8	66663				
25	49.7	49.8	63914				
30	49.9	49.7	66737				
40	52.7	52.5	66665				
50	53.2	53.2	66664				
75	53.1	53.1	62365				
100	49.6	49.3	66659	1.0288	62.8	1.02836	6
150	46.0	45.7	66659				
200	44.1	44.2	63914				
250	41.8	41.7	66737				
300	40.2	40.0	66665				
400	39.7	39.6	66664				
500	39.3	39.2	62365	1.0295	60.4	1.02873	6
Station No. 72 (J 12). Lat. 39° 22′ 00″ N.; Long. 71° 22′ 00″ W. August 19, 1889, 7 a. m.							
Surface	71.5	71.5	6812	1.0244	71.8	1.02531	
5	71.9	71.6	66656				
10	63.2	63.1	66661				
15	58.7	58.6	66724				
20	55.6	55.6	62365				
25	55.0	55.0	66664				
30	54.9	54.7	66665				
40	53.2	53.0	66737				
50	53.5	53.6	63914				
75	53.3	53.2	66663				
100	49.8	49.5	66659	1.0285	60.8	1.02778	6
150	44.7	44.6	62365				
200	42.7	42.6	66664				
250	42.0	41.8	66665				
300	40.4	40.3	66737				
400	39.3	39.4	63914				
500	39.2	39.1	66663	1.0298	61.4	1.02916	6
Station No. 73 (J 11). Lat. 39° 30′ 20″ N.; Long. 71° 21′ 30″ W. August 19, 1889, 11 a. m.							
Surface	72.3	72.3	6812	1.0244	73.8	1.02563	
5	72.1	71.8	66656				
10	64.7	64.6	66661				
15	55.5	55.5	66724				
20	52.0	51.7	66659				
25	52.3	52.2	66663				
30	51.8	51.9	63914				
40	54.1	53.9	66737				
50	54.5	54.3	66665				
75	52.0	52.0	66664				
100	49.4	49.4	62365	1.0295	61.0	1.02881	8
150	47.4	47.3	66663				
200	44.6	44.7	63914				
250	41.4	41.3	66737				
300	40.7	40.5	66665				
400	39.4	39.3	66664				
500	39.2	39.1	62365	1.0296	63.8	1.02930	6
Station No. 74 (J 10). Lat. 39° 40′ 20″ N.; Long. 71° 21′ 30″ W. August 19, 1889, 2 p. m							
Surface	72.0	72.0	6812	1.0243	74.0	1.02557	
5	71.5	71.2	66656				
10	71.8	71.7	66661				
15	52.0	52.0	66724				
20	47.2	46.9	66659				
25	47.2	47.1	66663				
30	49.3	49.4	63914				
40	52.0	51.8	66737				
50	55.4	55.2	66665				
75	53.9	53.9	66664				
100	51.2	51.2	62365	1.0296	61.2	1.02894	8
150	47.2	47.1	66663				
200	44.7	44.8	63914				
250	42.1	42.0	66737				
300	40.8	40.6	66665				
400	39.6	39.5	66664				
500	39.3	39.2	62365	1.0298	60.8	1.02908	8
Station No. 75 (J 9). Lat. 39° 52′ 00″ N.; Long. 71° 19′ 00″ W. August 19, 1889, 4 p. m.							
Surface	71.5	71.5	6812	1.0244	72.4	1.02541	
5	71.3	71.0	66656				
10	65.0	64.9	66724				
15	57.8	57.6	66659				
20	47.5	47.4	66663				
25	47.7	47.8	63914				
30	48.4	48.2	66737				
40	52.7	52.5	66665				
50	53.5	53.5	66664				
75	52.8	52.8	62365				
100	52.5	52.2	66659	1.0296	56.8	1.02840	6
125	49.0	48.9	66663				
150	53.1	53.2	63914				
200	44.0	43.9	66737				
250	42.0	41.8	66665				
300	40.1	40.0	66664				
350	39.7	39.6	62365				
380			5320	1.0296	56.0	1.02830	6
Station No. 76 (J 8). Lat. 40° 2′ 00″ N.; Long. 71° 21′ 00″ W. August 19, 1889, 7 p. m.							
Surface	71.0	71.0	6812	1.0243	72.0	1.02525	
5	71.0	70.7	66656				
10	71.1	71.2	66726				
15	54.5	54.3	66731				
20	57.4	57.5	62365				
25	46.0	45.9	66664				
30	46.0	45.8	66665				
40	47.1	46.9	66737				
50	50.8	50.9	63914				
75	52.1	52.0	66663				
100	50.1	49.8	66659				
102			5320	1.0282	58.0	1.02714	6
Station No. 77 (J 7). Lat. 40° 12′ 00″ N.; Long. 71° 20′ 00″ W. August 19, 1889, 10 p. m.							
Surface	71.2	71.2	6812	1.0242	72.0	1.02514	
5	71.0	70.7	66656				
10	67.4	67.3	66659				
15	68.0	67.9	66663				
20	54.1	54.2	63914				
25	46.0	45.9	66737				
30	47.0	46.8	66665				
40	47.3	47.3	66664				
50	47.2	47.2	62365				
52			5320	1.0276	58.0	1.02654	8

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 78 (J 6). Lat. 40° 22′ 00″ N.; Long. 71° 20′ 00″ W. August 19, 1889, 12 p. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	71.0	71.0	6812	1.0240	71.6	1.02488	
5	71.0	70.7	66656				
10	71.4	71.3	66663				
15	71.0	71.0	*63914				
20	48.4	48.2	66737				
25	46.6	46.4	66665				
30	46.0	45.9	66664				
45	44.3	44.2	62365				
46			5320	1.0276	55.5	1.02624	8

Station No. 79 (J 5). Lat. 40° 32′ 00″ N.; Long. 71° 20′ 00″ W. August 20, 1889, 1 a. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	71.2	71.2	6812	1.0242	72.7	1.02526	
5	71.2	70.9	66656				
10	71.0	70.9	66663				
15	60.0	60.0	63914				
20	52.2	52.0	66737				
25	48.0	47.8	66665				
30	51.0	51.0	66664				
40	44.6	44.5	62365				
42			5320	1.0272	66.4	1.02799	8

Station No. 80 (J 4). Lat. 40° 42′ 00″ N.; Long. 71° 20′ 00″ W. August 20, 1889, 3 a. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	70.5	70.5	6812	1.0239	72.0	1.02484	
5	70.4	70.3	66663				
10	70.0	69.7	66656				
15	61.6	61.7	62365				
20	50.2	50.2	66664				
25	48.4	48.2	66665				
30	48.0	47.8	66737				
35			5320	1.0262	64.8	1.02604	8

Station No. 81 (J 3). Lat. 40° 52′ 00″ N.; Long. 71° 20′ 00″ W. August 20, 1889, 6 a. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	68.8	68.8	6812	1.0244	70.1	1.02505	
5	69.0	68.7	66656				
10	52.3	52.3	62365				
15	48.0	48.0	66664				
20	47.0	46.8	66665				
25	45.3	45.2	66737				
34	45.2	45.1	66663	1.0270	54.5	1.02554	8

Station No. 82 (K 3). Lat. 40° 52′ 00″ N.; Long. 71° 30′ 00″ W. August 20, 1889, 10 a. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	69.2	69.2	6812	1.0243	70.3	1.02498	
5	69.7	69.4	66656				
10	68.0	68.0	63914				
15	67.2	67.0	66665				
20	45.5	45.4	66664				
25	45.4	45.3	62365				
30	45.0	44.4	66663				
34	44.8	44.7	66737	1.0272	57.9	1.02613	8

Station No. 83 (K 4). Lat. 40° 42′ 00″ N.; Long. 71° 30′ 00″ W. August 20, 1889, 1 p. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	69.9	69.9	6812	1.0240	72.8	1.02507	
5	69.0	68.7	66656				
10	55.5	55.3	66663				
15	48.6	48.4	66665				
20	45.5	45.4	66664				
25	44.5	44.4	62365				
30	44.3	44.4	63914				
35	44.0	43.9	66737				
36			5320	1.0268	61.0	1.02611	8

Station No. 84 (K 5). Lat. 40° 32′ 00″ N.; Long. 71° 30′ 00″ W. August 20, 1889, 3 p. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	71.4	71.4	6812	1.0236	72.1	1.02456	
5	70.7	70.4	66656				
10	68.0	68.0	66737				
15	67.8	67.8	63914				
20	51.2	51.2	62365				
25	45.3	45.2	66664				
30	44.6	44.4	66665				
38	44.4	44.3	66663	1.0268	55.4	1.02543	8

Station No. 85 (K 6). Lat. 40° 22′ 00″ N.; Long. 71° 30′ 00″ W. August 20, 1889, 5 p. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	71.8	71.8	6812	1.0233	73.8	1.02453	
5	71.8	71.5	66656				
10	53.7	53.5	66737				
15	50.3	50.4	63914				
20	49.7	49.7	62365				
25	46.1	46.0	66664				
30	46.3	46.1	66665				
40	45.0	44.9	66663				
42			5320	1.0282	59.2	1.02728	8

Station No. 86 (K 7). Lat. 40° 12′ 00″ N.; Long. 71° 30′ 00″ W. August 20, 1889, 7 p. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	71.9	71.9	6812	1.0233	72.5	1.02432	
5	72.0	71.7	66656				
10	71.0	70.9	66659				
15	59.2	59.2	66737				
20	48.0	48.1	63914				
25	46.4	46.3	62365				
30	45.5	45.4	66664				
40	45.0	44.8	66665				
47	46.0	45.9	66663	1.0268	57.6	1.02569	8

Station No. 87 (K 8). Lat. 40° 2′ 00″ N.; Long. 71° 30′ 00″ W. August 20, 1889, 9 p. m.

Depth (fath.).	Temperature.			Specific Gravity.			
	Obs.	Corr.	Therm. No.	Obs.	Temp.	Reduced.	Cup No.
Surface	71.8	71.8	6812	1.0234	73.4	1.02457	
5	71.2	70.9	66656				
10	71.0	70.9	66659				
15	69.0	68.7	66665				
20	64.5	64.4	66664				
25	51.5	51.5	62365				
30	46.8	46.9	63914				
40	46.0	45.9	66737				
50	48.7	48.6	66663	1.0264	64.7	1.02623	8

* Thermometer did not reverse.

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 88 (K 9). Lat. 39° 52′ 00″ N.; Long. 71° 30′ 00″ W. August 20, 1889, 11 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced	Specific Gravity. Cup No.
Surface	71.3	71.3	6812	1.0238	72.8	1.02487	
5	71.2	70.9	66656				
10	71.3	71.1	52728				
15	58.0	57.9	66661				
20	60.5	60.2	66724				
25	45.5	45.4	66663				
30	49.8	49.6	66737				
40	49.0	49.1	63914				
50	53.0	53.0	62365				
75	52.1	52.1	66664				
100	46.6	46.4	66665				
160	45.0	44.7	66659				
166			5320	1.0276	60.6	1.02686	8

Station No. 89 (K 10). Lat. 39° 42′ 00″ N.; Long. 71° 30′ 00″ W. August 21, 1889, 2 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced	Specific Gravity. Cup No.
Surface	72.3	72.3	6812	1.0241	73.7	1.02532	
5	72.2	71.9	66656				
10	72.0	71.9	66661				
15	64.1	64.0	66724				
20	55.2	55.1	66663				
25	48.8	48.6	66737				
30	49.0	49.1	63914				
40	52.2	52.2	62365				
50	54.0	54.0	66664				
75	54.0	53.8	66665				
100	52.0	51.7	66659	1.0268	70.5	1.02751	8
150	47.0	46.8	66737				
200	43.8	43.9	63914				
250	41.6	41.5	62365				
300	40.1	40.0	66664				
400	39.7	39.5	66665				
500	39.5	39.2	66659	1.0275	58.5	1.02650	8

Station No. 90 (K 11). Lat. 39° 32′ 00″ N.; Long. 71° 30′ 00″ W. August 21, 1889, 7 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced	Specific Gravity. Cup No.
Surface	72.4	72.4	6812	1.0243	73.6	1.02550	
5	71.1	70.7	66656				
10	60.6	60.5	66661				
15	54.0	54.0	66724				
20	52.4	52.3	66663				
25	50.0	49.8	66737				
30	50.1	50.2	63914				
40	52.6	52.6	62365				
50	54.5	54.5	66664				
75	53.7	53.5	66665				
100	50.0	49.7	66659	1.0274	65.7	1.02737	8
150	46.9	46.8	62365				
200	44.4	44.3	66 64				
250	41.8	41.6	66665				
300	40.8	40.5	66659				
400	40.0	39.7	66656				
500	39.6	39.7	63914	1.0280	60.0	1.02718	8

Station No. 91 (K 12). Lat. 39° 22′ 00″ N.; Long. 71° 30′ 00″ W. August 21, 1889, 1 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	74.8	74.8	6812	1.0242	76.5	1.02590	
5	72.5	72.2	66656				
10	59.0	58.9	66664				
15	47.4	47.2	66665				
20	49.8	49.6	66737				
25	57.2	51.1	66663				
30	49.1	49.1	66724				
40	51.0	50.8	66661				
50	53.1	52.8	66659				
75	53.0	53.1	63914				
100	50.1	50.1	62365	1.0280	62.7	1.02755	8
150	45.4	45.5	63914				
200	43.5	43.2	66659				
250	41.7	41.6	66661				
300	40.1	40.2	66724				
400	39.6	39.5	66663				
500	39.1	39.0	66737	1.0280	53.5	1.02644	8

Station No. 92 (H 12). Lat. 39° 22′ 00″ N.; Long. 71° 10′ 00″ W. August 21, 1889, 7 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	74.2	74.2	6812	1.0242	75.7	1.02576	
5	71.6	71.3	66656				
10	62.3	62.2	66724				
15	55.7	55.5	66665				
20	54.0	53.7	66659				
25	52.0	52.0	66664				
30	52.1	51.9	66661				
40	53.1	53.1	66724				
50	54.5	54.4	66663				
75	54.0	53.8	66737				
100	53.0	52.8	62365	1.0282	62.4	1.02771	8
150	48.0	47.8	66656				
200	43.1	42.9	66665				
250	41.3	41.2	66737				
300	41.0	40.9	66663				
400	40.0	40.1	66724				
500	39.4	39.3	66661	1.0298	58.8	1.02884	8

Station No. 93 (H 11). Lat. 39° 32′ 00″ N.; Long. 71° 10′ 00″ W. August 21, 1889, 10 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	73.4	73.4	6812	1.0240	75.2	1.02548	
5	71.0	70.8	66656				
10	69.2	69.0	52728				
15	60.5	60.5	63914				
20	61.0	60.8	66659				
25	48.0	47.7	66661				
30	49.0	48.8	66665				
40	51.7	51.5	66737				
50	53.8	53.7	66663				
75	54.0	54.0	66664				
100	51.2	51.2	66724	1.0290	64.2	1.02876	8
150	47.6	47.4	66656				
200	44.6	44.7	66724				
250	41.8	41.7	66663				
300	40.5	40.4	66737				
400	39.9	39.7	66665				
500	39.4	39.3	66661	1.0285	65.4	1.02843	8

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 94 (H 10). Lat. 39° 42′ 00″ N.; Long. 71° 10′ 00″ W. August 22, 1889, 1 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.9	72.9	6812	1.0242	74.3	1.02552	
5	72.0	71.7	66656				
10	62.7	62.7	63914				
15	47.3	47.1	66661				
20	46.1	45.8	66659				
25	46.8	46.6	66665				
30	49.1	49.0	66737				
40	50.0	49.9	66663				
50	54.2	54.2	66664				
75	54.3	54.3	66724				
100	52.0	52.0	62365	1.0273	66.5	1.02739	8
150	47.0	46.7	66659				
200	45.2	45.0	66665				
250	42.2	42.1	66737				
300	41.0	40.9	66663				
400	40.0	39.9	66664				
500	39.3	39.4	66724	1.0274	64.0	1.02713	8

Station No. 95 (H 9). Lat. 39° 51′ 00″ N.; Long. 71° 10′ 00″ W. August 22, 1889, 4 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.0	72.0	6812	1.0242	73.5	1.02538	
5	71.3	71.0	66656				
10	70.3	70.3	62365				
15	52.0	52.1	66724				
20	47.5	47.5	66664				
25	48.0	47.9	66663				
30	50.1	49.9	66737				
40	57.0	56.8	66665				
50	55.7	55.4	66659				
75	53.3	53.1	66661				
100	50.0	50.1	63914	1.0282	63.2	1.02782	8
150	45.2	45.1	66663				
200	43.4	43.3	66737				
250	41.0	40.8	66665				
300	40.0	39.7	66659				
400	39.8	39.7	66661				
450	39.4	39.5	63914				
453			5320	1.0278	58.6	1.02681	8

Station No. 96 (H 8). Lat. 40° 2′ 00″ N.; Long. 71° 10′ 00″ W. August 22, 1889, 7 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	70.8	70.8	6812	1.0242	72.2	1.02518	
5	64.5	64.4	66656				
10	67.2	67.0	52728				
15	58.0	58.0	66724				
20	57.0	57.0	62365				
25	52.2	52.2	66664				
30	55.6	55.5	66663				
40	48.7	48.5	66737				
50	47.5	47.3	66665				
75	55.0	54.7	66659				
100	50.5	50.3	66661				
150	46.3	46.4	63914				
160			5320	1.0276	64.8	1.02744	8

Station No. 97 (G 7). Lat. 40° 12′ 00″ N.; Long. 71° 3′ 00″ W. August 22, 1889, 9 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	71.8	71.8	6812	1.0240	73.4	1.02517	
5	57.0	56.9	66656				
10	55.3	55.0	52728				
15	52.0	52.0	66664				
20	51.6	51.5	66663				
25	50.2	50.0	66737				
30	47.6	47.4	66665				
40	47.0	46.7	66659				
50	47.1	47.0	66661				
75	50.6	50.7	63914				
87			5320	1.0278	64.7	1.02763	8

Station No. 98 (H 6). Lat. 40° 22′ 00″ N.; Long. 71° 6′ 00″ W. August 22, 1889, 11 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.0	72.0	6812	1.0241	73.8	1.02533	
5	68.0	67.9	66656				
10	64.0	63.9	*66661				
15	57.2	57.2	63914				
20	56.1	56.0	66661				
25	48.1	47.8	66659				
30	47.0	46.8	66665				
40	45.4	45.3	66737				
50	45.0	44.9	66663				
52			5320	1.0262	64.2	1.02596	8

Station No. 99 (H 5). Lat. 40° 32′ 00″ N.; Long. 71° 10′ 00″ W. August 22, 1889, 2 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	73.2	73.2	6812	1.0237	73.7	1.02492	
5	71.3	71.0	66656				
10	67.6	67.6	63914				
15	65.3	65.2	66661				
20	51.0	50.7	66659				
25	47.1	46.9	66665				
30	46.3	46.1	66737				
40	45.5	45.4	66663				
45			5320	1.0264	64.6	1.02621	8

Station No. 100 (H 4). Lat. 40° 42′ 00″ N.; Long. 70° 14′ 00″ W. August 22, 1889, 7 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.8	72.8	6812	1.0238	73.6	1.02500	
5	71.7	71.4	66656				
10	65.0	64.9	66664				
15	51.5	51.3	66661				
20	47.0	46.8	66659				
25	45.0	44.9	*66663				
30	44.2	44.1	66737				
39	45.3	45.2	*66663	1.0270	57.2	1.02584	8

Station No. 101 (H 3). Lat. 40° 52′ 00″ N.; Long. 71° 15′ 00″ W. August 22, 1889, 12 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	70.6	70.6	6812	1.0239	71.8	1.02481	
5	69.6	69.3	66656				
10	56.1	55.9	66661				
15	51.0	50.7	66659				
20	46.2	46.1	66664				
25	45.0	44.9	66737				
30	45.4	45.3	66663				
32			5320	1.0264	56.8	1.02520	8

* Thermometer did not reverse.

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 102 (J 1). Lat. 41° 12′ 00″ N.; Long. 71° 20′ 00″ W. August 27, 1889, 9 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	64.5	64.5	6812	1.0246	63.4	1.02425	
5	64.0	63.9	66656				
10	63.7	63.6	66664				
15	54.8	54.6	66737				
20	53.0	52.9	66663				
22			5320	1.0262	60.0	1.02538	8

Station No. 103 (J 2). Lat. 41° 2′ 00″ N.; Long. 71° 2′ 0″ 00 W. August 27, 1889, 11 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	64.3	64.3	6812	1.0244	60.3	1.02362	
5	64.3	64.2	66656				
10	64.0	63.9	66661				
15	61.8	61.6	66659				
20	55.4	55.4	66664				
25	51.3	51.1	66737				
30	50.2	50.1	66663	1.0259	61.0	1.02521	8

Station No. 104 (K 1). Lat. 41° 12′ 00″ N.; Long. 71° 30′ 00″ W. August 31, 1889, 12 m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.3	67.3	6812	1.0240	69.4	1.02453	
5	64.7	64.6	66656				
13	64.5	64.4	66663				
20	64.0	64.0	66737	1.0241	70.8	1.02485	8

Station No. 105 (K 2). Lat. 41° 2′ 00″ N.; Long. 71° 31′ 15″ W. August 31, 1889, 6 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	68.2	68.2	6812	1.0240	69.1	1.02448	
5	66.0	65.9	66656				
10	63.6	63.6	66737				
15	62.0	61.8	66659				
20	56.3	56.2	66663				
25	51.7	51.7	66664				
26			5320	1.0252	61.6	1.02459	8

Station No. 106 (K 3). Lat. 40° 52′ 00″ N.; Long. 71° 30′ 00″ W. August 31, 1889, 9 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.2	67.2	6812	1.0241	68.7	1.02452	
5	66.8	66.7	66656				
10	66.8	66.7	66661				
15	61.8	61.6	66659				
20	51.2	51.2	66664				
25	56.3	56.2	66663				
30	47.0	46.9	66737				
34			5320	1.0255	60.0	1.02468	8

Station No. 107 (K 4). Lat. 40° 42′ 00″ N.; Long. 71° 30′ 00″ W. August 31, 1889, 11 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.2	67.2	6812	1.0241	68.2	1.02445	
5	69.0	68.7	66656				
10	66.0	65.7	66665				
15	64.3	64.2	66661				
20	53.4	53.1	66659				
25	47.0	47.0	66664				
30	53.4	53.3	66663				
35	46.0	45.9	66737				
36			5320	1.0262	57.0	1.02502	8

Station No. 108 (K 5). Lat. 40° 32′ 00″ N.; Long. 71° 30′ 00″ W. August 31, 1889, 12 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	66.5	66.5	6812	1.0246	68.0	1.02492	
5	65.8	65.7	66656				
10	66.2	65.9	66665				
15	65.2	65.1	66661				
20	51.5	51.2	66659				
25	49.4	49.4	66664				
30	51.8	51.6	66737				
35	45.7	45.6	66663				
37			5320	1.0263	63.4	1.02595	8

Station No. 109 (J 3). Lat. 40° 52′ 00″ N.; Long. 71° 20′ 00″ W. September 1, 1889, 12 m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	65.3	65.3	6812	1.0248	67.0	1.02497	
5	64.3	64.2	66656				
10	64.3	64.0	66665				
15	58.6	58.5	66661				
20	59.8	59.6	66659				
25	56.0	56.0	66664				
30	52.6	52.4	66737				
35	47.5	47.4	66663	1.0261	57.5	1.02498	8

Station No. 110 (J 4). Lat. 40° 42′ 00″ N.; Long. 71° 20′ 00″ W. September 1, 1889, 2 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.4	67.4	6812	1.0246	68.6	1.02501	
5	67.2	67.1	66656				
10	66.0	65.7	66665				
15	58.0	57.9	66661				
20	51.1	50.8	66659				
25	46.1	46.0	66664				
30	46.0	45.8	66737				
33	46.0	45.9	66663				
34			5320	1.0264	51.2	1.02461	8

Station No. 111 (J 5). Lat. 40° 32′ 00″ N.; Long. 71° 20′ 00″ W. September 1, 1889, 3 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.1	67.1	6812	1.0245	67.5	1.02474	
5	66.0	65.9	66656				
10	66.0	65.7	66665				
15	66.4	66.3	66661				
20	64.0	63.8	66659				
25	53.5	53.5	66664				
30	48.9	48.7	66737				
40	47.6	47.5	66663	1.0265	57.2	1.02534	8

Station No. 112 (J 6). Lat. 40° 22′ 00″ N.; Long. 71° 20′ 00″ W. September 1, 1889, 5 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	66.0	66.0	6812	1.0252	67.3	1.02541	
5	66.2	66.1	66656				
10	65.7	65.4	66665				
15	64.2	64.1	66661				
20	63.0	62.8	66659				
25	49.2	49.2	66664				
30	48.0	47.8	66737				
40	46.0	45.9	66663				
43			5320	1.0260	54.0	1.02449	8

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 113 (J 7). Lat. 40° 12′ 00″ N.; Long. 71° 20′ 00″ W. September 1, 1889, 7 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.5	67.5	6812	1.0254	68.2	1.02575	
5	68.2	67.9	66656				
10	67.8	67.8	63914				
15	68.0	67.7	*66665				
20	59.8	59.7	66661				
25	52.2	52.0	66659				
30	49.5	49.5	66664				
40	49.8	49.7	66737				
47	46.2	46.1	66663				
48			5320	1.0260	54.8	1.02457	8

Station No. 114 (H 1). Lat. 41° 12′ 00″ N.; Long. 71° 1′ 00″ W. September 2, 1889, 11 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	65.2	65.2	6812	1.0246	66.4	1.02468	
5	64.1	64.0	66656				
10	62.7	62.6	66664				
15	61.2	61.2	66737				
20	56.1	56.0	66663				
23			5320	1.0260	61.6	1.02539	8

Station No. 115 (H 2). Lat. 41° 2′ 00″ N.; Long. 71° 10′ 00″ W. September 3, 1889, 1 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	65.5	65.5	6812	1.0244	67.0	1.02457	
5	64.8	64.7	66656				
10	64.6	64.4	66659				
15	57.1	57.0	66664				
20	55.0	54.8	66737				
25	51.6	51.5	66663				
27			5320	1.0260	57.7	1.02490	8

Station No. 116 (H 3). Lat. 40° 52′ 00″ N.; Long. 71° 10′ 00″ W. September 3, 1889, 4 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	65.1	65.1	6812	1.0251	66.5	1.02519	
5	65.4	65.3	66656				
10	64.0	63.9	66661				
15	60.2	60.1	66663				
20	52.2	52.0	66737				
25	49.2	49.2	66664				
30	47.6	47.3	66659				
32			6320	1.0260	63.7	1.02569	8

Station No. 117 (H 4). Lat. 40° 42′ 00″ N.; Long. 71° 10′ 00″ W. September 3, 1889, 7 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	65.7	65.7	6812	1.0250	66.7	1.02512	
5	66.0	65.9	*66656				
10	56.8	56.6	66661				
15	50.3	50.2	66663				
20	48.4	48.2	66737				
25	47.5	47.5	66664				
30	47.0	46.7	66659				
33			5320	1.0261	57.9	1.02503	8

Station No. 118 (H 5). Lat. 40° 31′ 00″ N.; Long. 71° 10′ 00″ W. September 3, 1889, 11 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.8	67.8	6812	1.0248	68.7	1.02522	
5	66.4	66.3	66656				
10	65.7	65.6	66665				
15	60.3	60.2	66661				
20	50.5	50.4	66663				
25	48.6	48.4	66737				
30	46.8	46.7	66664				
40	46.6	46.3	66659				
40½			5320	1.0268	57.0	1.02562	8

Station No. 119 (H 6). Lat. 40° 22′ 00″ N.; Long. 71° 10′ 00″ W. September 3, 1889, 3 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.6	67.6	6812	1.0243	69.4	1.02483	
5	67.0	66.7	66656				
10	67.5	67.5	63914				
15	66.0	65.7	66665				
20	57.2	57.1	66661				
25	55.0	54.9	66663				
30	52.0	51.8	66737				
40	45.2	45.1	66664				
48	46.0	45.7	66659				
49			5320	1.0260	59.7	1.02514	8

Station No. 120 (H 7). Lat. 40° 12′ 00″ N.; Long. 71° 10′ 00″ W. September 3, 1889, 10 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	70.2	70.2	6812	1.0249	70.6	1.02562	
5	70.0	69.7	66656				
10	70.4	70.2	52728				
15	64.9	64.9	63914				
20	54.0	53.8	66665				
25	49.3	49.1	66661				
30	49.0	48.9	66663				
40	46.6	46.5	66737				
50	49.0	49.0	66664				
75	50.9	50.6	66659				
76			5320	1.0280	58.0	1.02694	8

Station No. 121 (H 8). Lat. 40° 2′ 00″ N.; Long. 71° 10′ 00″ W. September 4, 1889, 2 a. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	69.6	69.6	6812	1.0253	69.6	1.02586	
5	70.3	70.0	66656				
10	66.2	66.0	52728				
15	60.2	60.2	*63914				
20	48.3	48.1	66665				
25	48.0	47.7	66660				
30	46.3	46.2	66661				
40	47.0	46.8	66737				
50	50.0	50.0	66664				
75	52.0	51.7	66659				
100	50.5	50.5	66664				
145	46.1	45.8	66659				
151			5320	1.0276	59.1	1.02667	8

Station No. 122 (H 10). Lat. 39° 42′ 00″ N.; Long. 71° 13′ 00″ W. September 4, 1889, 8 p. m.

Depth (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	72.2	72.2	6812	1.0242	73.2	1.02534	
5	69.8	69.5	66656				
10	68.0	68.0	66724				
15	58.3	57.9	52728				
20	53.9	54.0	63914				
25	50.0	49.8	66665				
30	52.2	52.0	66661				
40	55.2	55.1	66663				
50	54.0	53.8	66737				
75	51.0	51.0	66664				
100	47.8	47.5	66659	1.0274	59.9	1.02657	8
150	47.0	46.8	66665				
200	42.2	42.1	66661				
250	40.7	40.6	66663				
300	39.9	39.8	66737				
400	39.8	39.7	66664				
500	39.1	38.8	66659	1.0275	60.0	1.02668	8

* Thermometer did not reverse.

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 123 (H 11). Lat. 39° 32′ 00″ N.; Long. 71° 10′ 00″ W. September 4, 1889, 11 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	69.9	69.9	6812	1.0244	71.8	1.02531	
5	70.1	69.8	66656				
10	68.5	68.5	62365				
15	62.0	61.9	66724				
20	57.2	56.8	52728				
25	51.8	51.8	66664				
30	50.3	50.1	66737				
40	54.8	54.7	66663				
50	55.8	55.6	66661				
75	53.0	52.8	66665				
100	49.8	49.9	63914	1.0280	60.1	1.02719	8
150	54.2	54.0	66665				
200	44.3	44.2	66661				
250	42.1	42.0	66663				
300	40.2	40.1	66737				
400	40.1	40.0	66664				
500	39.4	39.2	66665	1.0270	65.9	1.02700	8

Station No. 124 (H 12). Lat. 39° 22′ 00″ N.; Long. 71° 10′ 00″ W. September 5, 1889, 3 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	69.1	69.1	6812	1.0248	70.8	1.02555	
5	69.1	68.8	66656				
10	68.8	68.8	66724				
15	58.0	57.6	52728				
20	54.5	54.5	66664				
25	50.7	50.5	66737				
30	49.8	49.7	66663				
40	54.0	53.8	66661				
50	54.5	54.3	66665				
75	53.8	53.9	63914				
100	51.3	51.0	66659	1.0276	62.6	1.02713	8
150	46.6	46.5	66737				
200	44.0	43.9	66663				
250	41.3	41.2	66661				
300	40.5	40.3	66665				
400	39.7	39.8	63914				
500	39.6	39.3	66659	1.0270	63.8	1.02670	8

Station No. 125 (G 12). Lat. 39° 29′ 00″ N.; Long. 71° 5′ 00″ W. September 5, 1889, 6 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	69.5	69.5	6812	1.0247	71.3	1.02538	
5	69.7	69.4	66656				
10	70.0	69.8	52728				
15	54.0	54.0	66724				
20	46.7	46.6	66664				
25	47.5	47.4	66737				
30	48.8	48.7	66663				
40	51.1	50.9	66661				
50	53.2	53.0	66665				
75	53.0	53.1	63914				
100	50.4	50.1	66659	1.0276	64.2	1.02736	8
150	46.0	45.9	66737				
200	43.7	43.6	66663				
250	41.6	41.5	66661				
300	40.3	40.1	66665				
400	39.6	39.7	63914				
500	39.3	39.0	66659	1.0276	61.4	1.02696	8

Station No. 126 (G 11). Lat. 39° 39′ 00″ N.; Long. 71° 5′ 00″ W. September 5, 1889, 9 a. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	70.3	70.3	6812	1.0244	73.0	1.02376	
5	69.3	69.0	66656				
10	68.8	68.6	52728				
15	56.2	56.2	66664				
20	52.7	52.5	66737				
25	50.5	50.4	66663				
30	57.8	57.7	66661				
40	56.2	56.2	66664				
50	56.0	55.8	66665				
75	52.7	52.8	63914				
100	50.1	49.8	66659	1.0274	64.7	1.02723	8
150	46.0	45.9	66737				
200	42.7	42.6	66663				
250	41.0	40.9	66661				
300	40.0	39.8	66665				
400	39.6	39.7	63914				
500	39.3	39.0	66659	1.0273	61.3	1.02665	8

Station No. 127 (G 10). Lat. 39° 49′ 00″ N.; Long. 71° 3′ 00″ W. September 5, 1889, 12 m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	70.1	70.1	6812	1.0245	73.3	1.02565	
5	69.0	68.7	66656				
10	69.0	69.0	66724				
15	56.0	55.6	52728				
20	53.0	53.0	66664				
25	50.0	49.8	66737				
30	50.5	50.4	66663				
40	52.5	53.3	66661				
50	53.3	53.1	66665				
75	51.2	51.3	63914				
100	48.6	48.3	66659	1.0276	59.6	1.02673	8
150	44.1	44.0	66737				
200	41.7	41.6	66663				
250	40.7	40.6	66661				
300	39.9	39.7	66665				
400	39.3	39.4	63914				
500	39.3	39.0	66659	1.0274	59.7	1.02654	8

Station No. 128 (G 9). Lat. 39° 52′ 00″ N.; Long. 71° 00′ 00″ W. September 5, 1889, 2 p. m.

Depth (fath.).	Temperature. Obs.	Temperature. Corr.	Temperature. Therm. No.	Specific Gravity. Obs.	Specific Gravity. Temp.	Specific Gravity. Reduced.	Specific Gravity. Cup No.
Surface	72.3	72.3	6812	1.0246	75.4	1.02611	
5	72.2	71.9	66656				
10	72.3	72.3	66724				
15	58.0	57.6	52728				
20	53.3	53.3	66664				
25	50.6	50.4	66737				
30	49.7	49.6	66663				
40	52.0	51.8	66661				
50	54.0	53.8	66665				
75	51.0	51.1	63914				
100	48.4	48.1	66659	1.0273	63.5	1.02696	8
150	46.0	45.9	66737				
200	45.0	44.9	66663				
250	41.4	41.3	66661				
300	40.9	40.7	66665				
400	39.5	39.6	63914				
465	39.3	39.0	66659				
472			5320	1.0277	51.5	1.02594	8

RECORD OF SERIAL TEMPERATURES AND DENSITIES—Continued.

Station No. 129 (G 8). Lat. 40° 2′ 00″ N.; Long. 71° 2′ 00″ W. September 5, 1889, 5 p. m.

Depth. (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	73.3	73.3	6812	1.0243	74.6	1.02567	
5	72.0	71.7	66656				
10	73.0	73.0	62365				
15	71.0	71.0	*66724				
20	62.0	61.6	52728				
25	57.3	57.2	66664				
30	57.3	57.1	66737				
40	52.0	51.9	66663				
50	53.1	52.9	66661				
75	51.2	51.0	66665				
100	48.4	48.5	63914				
150	46.0	45.7	66659				
157			5320	1.0274	59.2	1.02648	8

Station No. 130 (G 7). Lat. 40° 13′ 00″ N.; Long. 71° 1′ 30″ W. September 5, 1889, 7 p. m.

Depth. (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	72.9	72.9	6812	1.0254	74.5	1.02676	
5	72.0	71.7	66656				
10	73.0	73.0	66724				
15	70.0	69.8	52728				
20	51.0	51.0	66664				
25	66.0	66.0	66737				
30	56.0	55.9	66663				
40	49.7	49.5	66661				
50	54.2	54.0	66665				
70	49.3	49.4	63914				
74			5320	1.0272	61.6	1.02659	8

Station No. 131 (G 6). Lat. 40° 22′ 00″ N.; Long. 71° 1′ 00″ W. September 5, 1889, 9 p. m.

Depth. (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	73.0	73.0	6812	1.0254	74.0	1.02667	
5	73.0	72.7	66656				
10	73.0	72.8	66664				
15	72.8	72.8	66737				
20	55.9	55.8	66663				
25	48.0	47.8	66661				
30	47.3	47.1	66665				
40	47.6	47.7	63914				
50	47.0	46.7	66659				
52			5320	1.0261	63.1	1.02571	8

Station No. 132 (G 5). Lat. 40° 32′ 00″ N.; Long. 71° 00′ 00″ W. September 5, 1889, 12 p. m.

Depth. (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	68.5	68.5	6812	1.0248	70.8	1.02555	
5	68.5	68.2	66656				
10	67.5	67.5	66737				
15	65.2	65.1	66663				
20	54.2	54.0	66661				
25	50.0	49.8	66665				
30	48.0	48.1	63914				
40	46.8	46.5	66659				
42			5320	1.0261	61.3	1.02545	8

Station No. 133 (G 4). Lat. 40° 42′ 00″ N.; Long. 71° 00′ 00″ W. September 6, 1889, 2 a. m.

Depth. (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.6	67.6	6812	1.0252	69.5	1.02575	
5	67.7	67.4	66656				
10	67.1	67.1	66737				
15	60.5	60.4	66663				
20	52.2	52.0	66661				
25	50.5	50.3	66665				
30	48.4	48.5	63914				
35	46.5	46.2	66659				
37			5320	1.0264	57.7	1.02530	8

Station No. 134 (G 3). Lat. 40° 51′ 00″ N.; Long. 71° 00′ 00″ W. September 6, 1889, 5 a. m.

Depth. (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.1	67.1	6812	1.0250	68.7	1.02542	
5	66.2	66.1	66656				
10	64.3	64.2	66663				
15	56.0	55.8	66661				
20	50.1	49.9	66665				
25	49.3	49.4	63914				
30	46.0	45.7	66659				
31			5320	1.0255	62.3	1.02499	8

Station No. 135 (G 2). Lat. 41° 00′ 00″ N.; Long. 71° 00′ 00″ W. September 6, 1889, 8 a. m.

Depth. (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	67.0	67.0	6812	1.0245	69.6	1.02506	
5	66.0	65.9	66656				
10	64.3	64.2	66661				
15	56.6	56.4	66665				
20	52.0	52.1	63914				
25	50.2	49.9	66659				
27			5320	1.0256	59.6	1.02473	8

Station No. 136 (G 2). Lat. 41° 9′ 00″ N.; Long. 71° 00′ 00″ W. September 6, 1889, 12 m.

Depth. (fath.).	Temperature. Obs.	Corr.	Therm. No.	Specific Gravity. Obs.	Temp.	Reduced.	Cup No.
Surface	68.0	68.0	6812	1.0242	69.8	1.02480	
5	63.1	63.0	66656				
10	56.2	56.3	63914				
15	56.3	56.0	66659				
19			5320	1.0252	63.3	1.02483	8

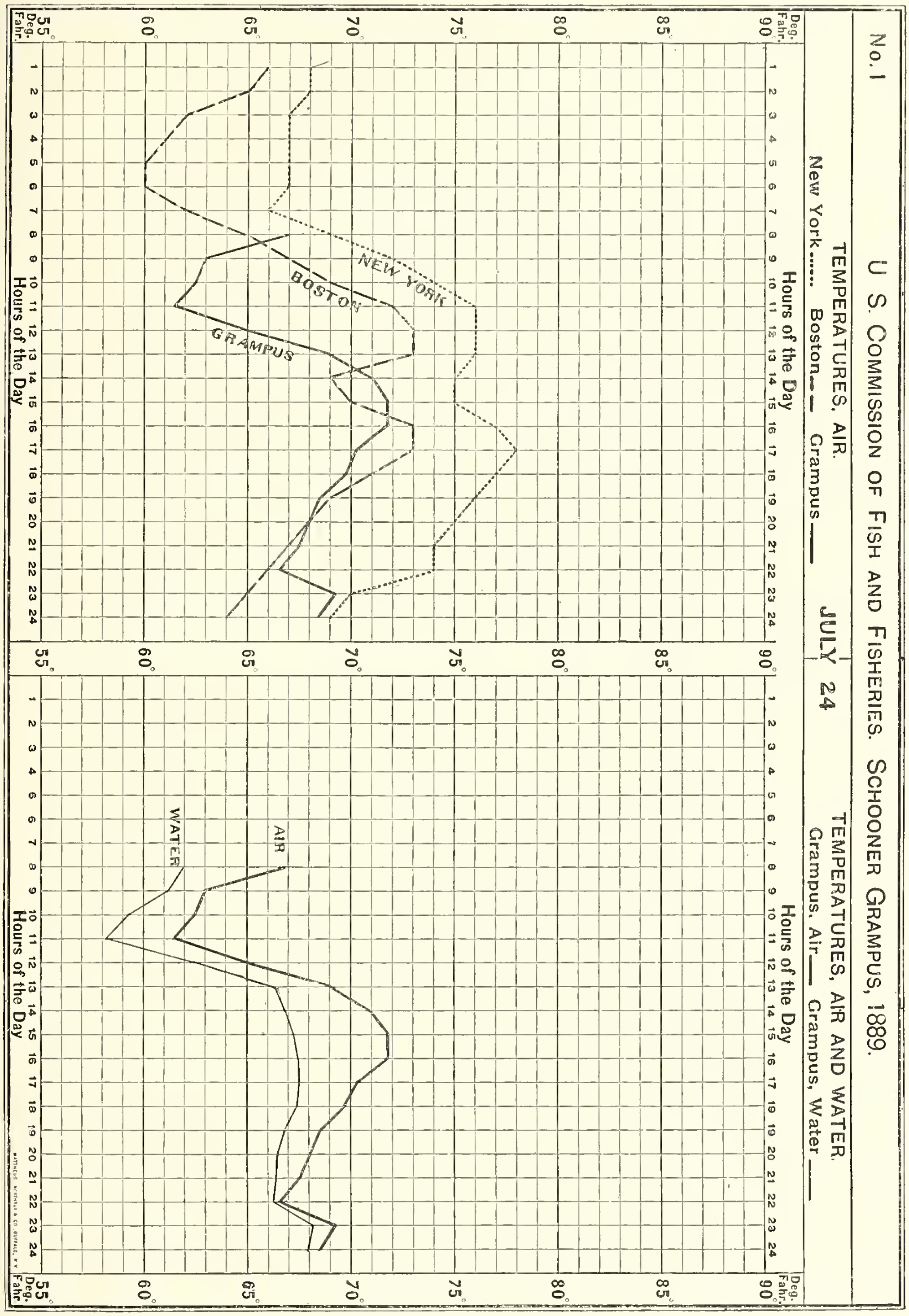
* Thermometer did not reverse.

Table 1.

Date, July 24, 1889. Solar radiation thermometer, 135° F. Maximum temperature, 72.8° F. Six's, 71.2° F.
Terrestrial radiation thermometer, 58° F. Minimum temperature, 61.8° F. Six's, 62° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0–10.	Upper.	Lower.	Direction.	Force.			
																		In.		
A. 2, No. 1	41° 7′ 0″ N., 70° 0′ 0″ W.	8	....	61.9	67.2	67.4	61.9	5.5	71.4	29.968	77.6	29.838	0	....	....	NW. by W.	3	0	Calm.....	Libbey.
		9	....	61.3	63.1	62.6	60.0	2.6	85.7	29.972	68.0	29.866	1	....	Str	W. by S.	3	....	...do	Do.
A. 3, No. 2*	40° 56′ 0″ N., 70° 0′ 0″ W.	10	....	59.4	62.6	62.5	59.8	2.7	85.5	30.012	66.8	29.911	1	....	Str	W. by S.	2	....	...do	Do.
		11	....	58.3	61.4	61.1	58.8	2.3	85.3	30.008	71.3	29.894	1	....	Str. cu.	S. by W.	2	....	...do	Do.
A. 4, No. 3	40° 46′ 39″ N., 70° 0′ 0″ W.	12	L. 0–18	62.8	65.1	65.0	62.1	2.9	83.6	30.030	67.5	29.927	1	....	Str. cu.	NW. by W.	3	....	...do	Do.
		13	....	66.3	69.0	69.4	64.2	5.2	74.8	30.026	70.3	29.915	2	....	Str. cu.	WNW.	3	....	Mod. sw.	Rockwood.
A. 5, No. 4	40° 35′ 0″ N., 70° 0′ 0″ W.	14	....	66.9	71.2	71.5	66.0	5.5	73.3	30.030	71.4	29.916	2	....	Cir. str.	WNW.	2	....	...do	Do.
		15	....	67.2	71.8	72.0	66.7	5.3	75.7	30.030	72.0	29.913	½	....	Cir. str.	SW. by W.	2	....	...do	Do.
		16	....	67.5	71.8	71.8	66.8	5.0	75.5	30.050	73.5	29.931	½	Cir	....	SW.	2	....	...do	Do.
A. 6, No. 5	40° 24′ 0″ N., 70° 0′ 0″ W.	17	H. 5–25	67.6	70.1	72.2	68.4	3.8	82.3	30.042	72.4	29.934	0	Str	....	SW. by W.	3	....	...do	Do.
		18	....	67.5	69.8	69.9	66.7	3.2	84.7	30.053	71.0	29.939	0	Str	....	SW. by W.	3	....	...do	Magie.
A. 7, No. 6	41° 13′ 0″ N., 70° 2′ 0″ W.	19	....	66.8	68.7	68.9	66.5	2.4	87.1	30.050	71.0	29.936	1	....	Str ...	WSW.	3	....	...do	Do.
		20	....	66.4	68.2	68.3	66.3	2.0	89.6	30.072	71.0	29.958	0	....	....	W. by S.	4	....	...do	Do.
A. 8, No. 7	40° 2′ 0″ N., 70° 3′ 0″ W.	21	....	66.5	67.8	67.5	65.0	2.5	86.8	30.094	70.8	29.982	0	....	....	W. by S.	4	....	...do	Libbey.
		22	....	66.3	66.6	66.4	65.0	1.4	91.9	30.106	70.2	29.995	0	....	....	W. by S.	5	....	...do	Do.
A. 9, No. 8	39° 51′ 0″ N., 70° 4′ 0″ W.	23	L. 11–40	68.2	69.2	69.1	67.0	2.1	89.6	30.100	71.2	29.986	0	....	....	W. by S.	5	....	...do	Do.
		24	....	68.0	68.6	69.0	67.0	2.0	89.6	30.098	71.0	29.984	0	....	....	W. by S.	5	....	...do	Do.

* South Shoal light-ship abeam.


No. 1
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York..... Boston— — Grampus——
JULY 24
TEMPERATURES, AIR AND WATER.
Grampus. Air—— Grampus, Water ——
Hours of the Day
NEW YORK
BOSTON
GRAMPUS
AIR
WATER
Deg. Fahr.
90°
85°
80°
75°
70°
65°
60°
55°

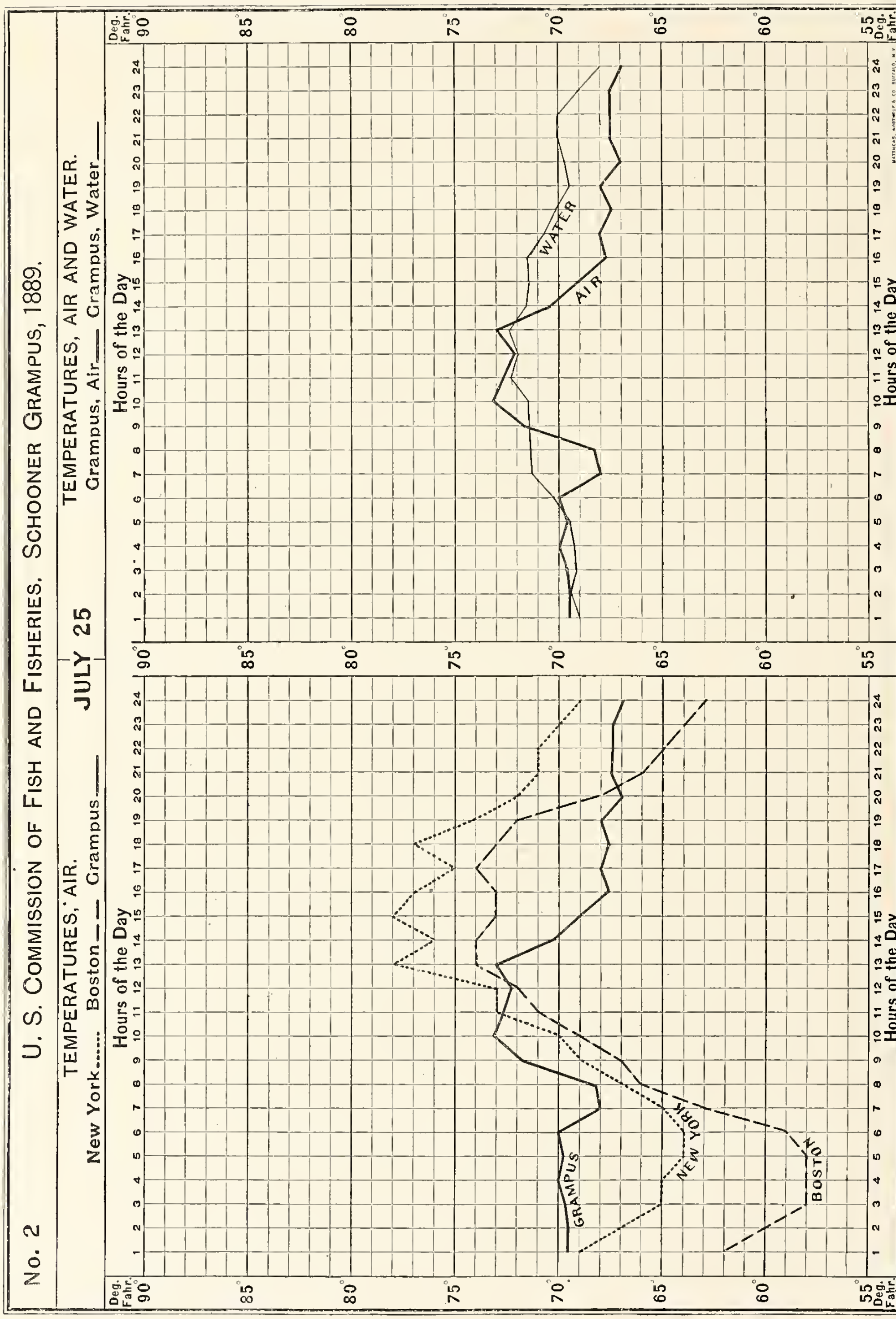

No. 2
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston— — Grampus——
JULY 25
TEMPERATURES, AIR AND WATER.
Grampus, Air—— Grampus, Water——
Hours of the Day
Deg. Fahr.
GRAMPUS
NEW YORK
BOSTON
WATER
AIR

TABLE 2.

Date, July 25, 1889. Solar radiation thermometer, 93.2° F. Maximum temperature, 73.6° F. Six's, 71.3° F.
Terrestial radiation thermometer, 65° F. Minimum temperature, 66.5° F. Six's, 67° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	*t.*	=32°.	0–10.	Upper.	Lower.	Direction.	Force.	*In.*		
A. 10, No. 9	39°40′0″N., 70°6′0″W.	1	....	69.0	69.6	69.4	67.3	2.1	89.6	30.100	71.0	29.986	0	....	....	W. by S.	4	....	Calm....	Rockwood.
		2	....	69.5	69.5	70.0	67.4	2.6	87.4	30.112	71.0	29.998	3	....	Str.....	W.	3	....	...do.....	Do.
		3	....	69.3	69.6	70.0	68.0	2.0	89.8	30.112	72.0	29.995	½	....	Str.....	W.	3	....	...do.....	Do.
		4	....	69.5	70.0	70.0	68.0	2.0	89.8	30.120	73.0	30.001	0	....	....	W.	3	....	...do.....	Do.
		5	....	69.7	69.8	69.9	68.0	1.9	89.8	30.126	73.0	30.007	8	Str.....	Cum ...	WSW.	4	....	Mod.sw.	Magie.
		6	H. 6–25	70.2	70.0	70.0	68.0	2.0	89.8	30.168	73.0	30.049	10	Nimbus.		WSW.	2	....	...do.....	Do.
		7	....	71.3	68.0	68.0	67.5	0.5	97.4	30.184	71.0	30.070	10	Nimbus.		NNW.	3	*.21	Rough ..	Do.
		8	....	71.4	68.2	68.2	67.0	1.2	94.8	30.188	72.5	30.070	10	Cu. Str.	Nim ...	....	0	....	...do.....	Do.
		9	....	71.5	71.8	71.9	69.5	2.4	87.7	30.204	73.4	30.083	10	Cu. Str.	Nim ...	WSW.	4	....	...do.....	Do.
		10	....	71.5	73.1	73.0	70.1	2.9	85.3	30.204	73.6	30.084	10	Cu. Str.	Nim ...	WSW.	4	....	.. do....	Libbey.
		11	....	72.4	72.8	73.0	70.3	2.7	87.6	30.214	69.0	30.105	10	Cu. Str.	Nim ...	N.	5	....	.. do. ..	Do.
		12	L. 0–57	72.0	72.3	72.6	70.0	2.6	87.7	30.232	72.0	30.115	10	Cu. Str.	Nim ...	NW. by W.	6	....	Calm. ..	Do.
B. 12, No. 10	39°27′0″N., 70°9′0″W.	13	....	72.6	73.0	73.0	70.5	2.5	87.8	30.220	74.3	30.098	10	Cir. Str.	Str	W. by S.	5	....	...do.....	Rockwood.
		14	....	71.5	70.2	70.4	66.0	3.4	82.1	30.220	72.5	30.102	10	Str	Str	WSW.	7	....	...do.....	Do.
		15	....	71.4	69.0	69.0	65.2	3.8	82.0	30.220	72.0	30.103	10	Nimbus.		WSW.	6	(†)	...do.....	Do.
C. 11, No. 11	39°34′0″N., 70°21′0″W.	16	....	71.5	67.8	68.2	64.8	3.4	81.6	30.228	72.3	30.111	10	Str	Cum ...	WSW.	4	(†)	...do.....	Libbey.
		17	....	70.8	68.0	68.2	66.1	2.1	89.6	30.230	72.0	30.113	9	Str	Cum ...	WSW.	4	.36	...do.....	Do.
C. 10, No. 12	39°44′0″N., 70°21′0″W.	18	H. 6–0	70.2	67.6	68.0	64.8	3.2	84.2	30.230	72.0	30.113	9	Str	Cum ...	WSW.	3	....	...do....	Do.
		19	....	69.5	68.0	68.0	65.4	2.6	86.9	30.230	72.0	30.113	5	Str	Cum ...	WSW.	3	....	.. do....	Do.
		20	....	69.7	67.0	67.3	65.0	2.3	87.2	30.230	72.0	30.113	5	Str	Cum ...	WSW.	1	...	...do....	Do.
		21	....	70.0	67.4	67.7	65.0	2.7	85.0	30.238	72.0	30.111	4	Str	....	WSW.	1	....	...do....	Rockwood.
		22	....	70.0	67.5	68.0	65.0	3.0	84.3	30.240	71.5	30.125	8	Nimbus.		WSW.	½	(†)	...do.....	Do.
C. 9, No. 13	39°54′0″N., 70°21′0″W.	23	....	69.0	67.5	68.0	65.5	2.5	87.0	30.240	71.0	30.126	10	Nimbus.		WSW.	½	(†)	...do.....	Do.
		24	L. 12–12	68.0	67.0	67.0	65.5	1.5	91.9	30.245	71.0	30.129	10	Nimbus.		WSW.	1	(†)	...do.....	Do.

* Rain squall. † Rain.

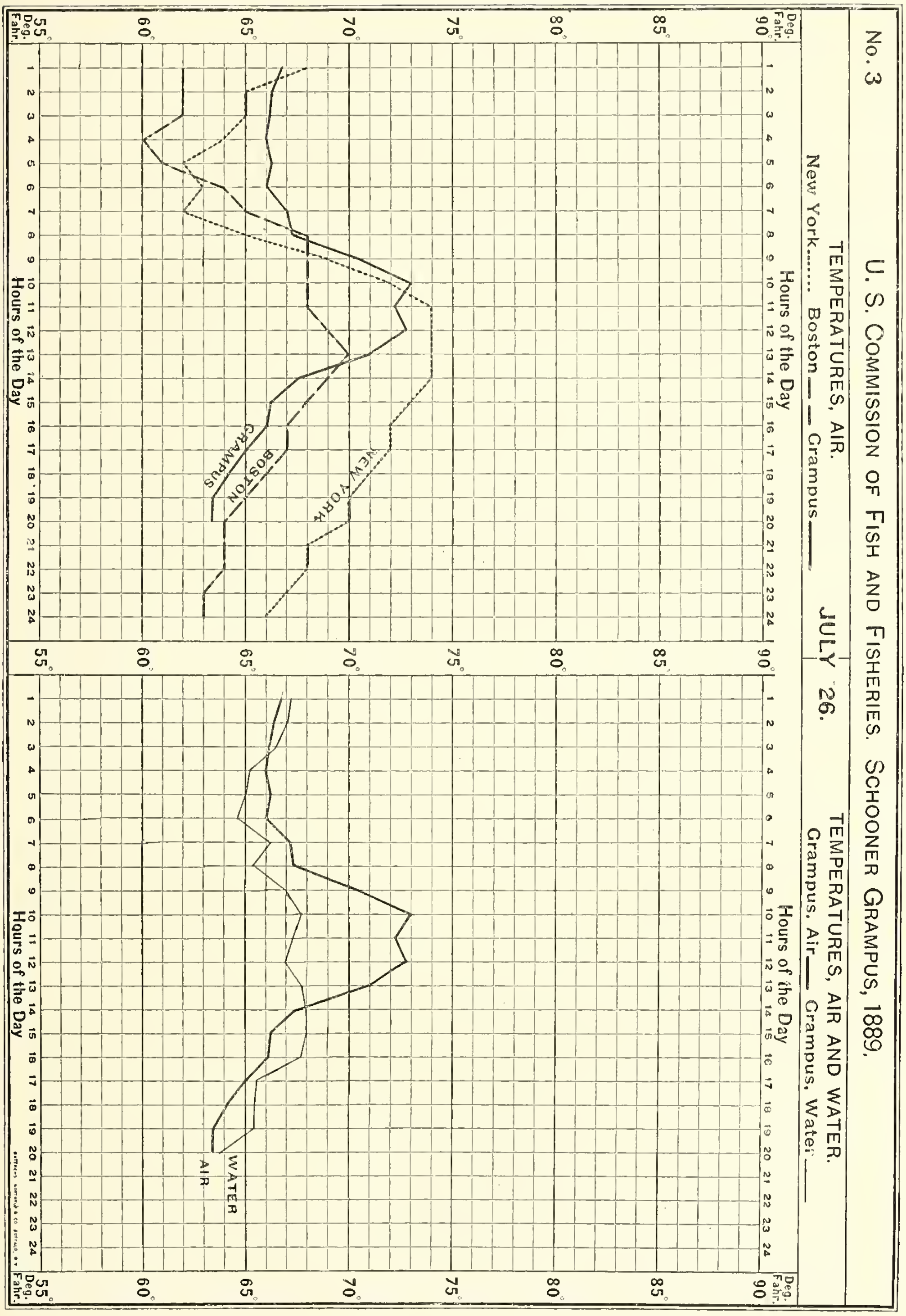
Table 3.

Date, July 26, 1889. Solar radiation thermometer, 140° F. Maximum temperature, 74.8° F. Six's, 74.2° F.
Terrestrial radiation thermometer, 63° F. Minimum temperature, 65° F. Six's, 65° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0—10.	Upper.	Lower.	Direction.	Force.	In.		
		1	....	67.1	66.8	67.0	66.3	0.7	97.5	30.242	76.0	30.115	10	Nimbus.		WSW.	1	(†)	Mod. sw.	Magie.
		2	....	67.0	66.3	66.5	66.0	0.5	97.3	30.228	70.3	30.117	10	Nimbus.		....	0	.42	...do	Do.
		3	....	66.5	66.2	66.3	65.0	1.3	92.5	30.222	70.5	30.110	10	Heavy fog.		ESE.	1	....	.. do	Do.
		4	....	65.3	66.0	66.0	65.0	1.0	94.5	30.226	69.9	30.115	9	....	Str.....	ENE.	2	....	...do	Do.
		5	....	65.2	66.2	66.0	65.3	0.7	97.4	30.226	70.2	30.115	9	....	Cir. str.	ENE.	1	....	Calm ...	Libbey.
C. 8, No. 14	40° 4′ 0″ N.; 70° 21′ 0″ W.	6	H. 6–58	64.8	66.0	66.0	65.2	0.8	97.5	30.242	70.0	30.131	8	....	Cir. str.	ENE.	1	....	...do	Do.
		7	....	66.3	67.2	67.5	66.2	1.3	93.8	30.258	71.4	30.144	9	....	Cir. str.	SE.	1	....	...do	Do.
		8	....	65.5	67.3	67.6	66.0	1.6	92.0	30.258	71.4	30.144	9	....	Cir. str.	SE.	1	....	...do	Do.
C. 7, No. 15	40° 14′ 0″ N.; 70° 21′ 0″ W.	9	....	67.0	70.4	70.6	67.8	2.8	85.8	30.256	73.0	39.137	4	....	Cir. str.	E.	2	....	...do	Rockwood.
		10	....	67.8	73.0	73.0	68.5	4.5	78.4	30.270	74.0	30.148	3	....	Cir. str.	E.	3	....	...do	Do.
C. 6, No. 16	40° 24′ 11″ N.; 70° 21′ 0″ W.	11	....	67.4	72.2	72.0	67.8	4.2	79.0	30.278	74.0	30.156	8	Cir	Cum ...	SE. by E.	3	....	...do	Do.
		12	....	67.0	72.7	72.4	68.0	4.4	78.3	30.280	74.0	30.158	8	....	Cum ...	ESE.	2	....	...do	Do.
C. 5, No. 17	40° 34′ 0″ N.; 70° 21′ 0″ W.	13	L. 1–31	67.9	71.0	71.0	67.0	4.0	80.2	30.286	73.0	30.167	...	Fog.		E.	3	...	...do	Magie.
		14	....	68.0	67.5	67.5	64.9	2.6	86.7	30.268	72.2	30.157	..	Fog.		E.	3	....	...do	Do.
C. 4, No. 18	40° 44′ 0″ N.; 70° 21′ 0″ W.	15	....	68.0	66.1	66.0	64.0	2.0	89.1	30.254	72.0	30.137	7	Cir. cu.	Str.....	E.	3	....	...do	Do.
		16	....	67.9	66.0	65.9	64.0	1.9	89.3	30.242	71.0	30.128	9	Cir. cu.	Str.....	E.	4	....	...do	Do.
C. 3, No. 19*	40° 54′ 0″ N.; 70° 21′ 0″ W.	17	....	65.4	65.0	64.6	63.0	1.6	91.6	30.244	70.2	30.133	8	Cir. cu.	Str.....	E.	4	....	...do	Libbey.
		18	H. 6–36	65.5	64.2	64.0	62.7	1.3	93.4	30.250	70.0	30.136	7	Cir. cu.	Str.....	ENE.	4	....	...do	Do.
C. 2, No. 20	41° 4′ 0″ N.; 70° 21′ 0″ W.	19	....	65.5	63.5	63.2	62.1	1.1	94.2	30.234	70.0	30.120	9	Cir. cu.	Str.....	E.	4	....	...do	Do.
		20	....	63.7	63.5	63.5	62.0	1.5	91.5	30.220	68.0	30.114	4	....	Str.....	E.	4	....	...do	Do.
		21	....	......	......	......	......	.....	......	....	......	....	...	....	....	....	...	....	....	
		22	....	......	......	......	......	.....	......	....	......	....	...	....	....	....	...	....	....	
		23	....	......	......	......	......	.....	......	....	......	....	...	....	....	....	...	....	....	
		24	L. 12–50	......	......	......	......	.....	......	....	......	....	...	....	....	....	...	....	....	

* Thermometer 5320 used for density temperatures from this time on, instead of 6795.

† Rain.


No. 3
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston — — Grampus ——
JULY 26.
TEMPERATURES, AIR AND WATER.
Grampus. Air —— Grampus, Water ——
Hours of the Day
Deg. Fahr.
GRAMPUS
BOSTON
NEW YORK
WATER
AIR

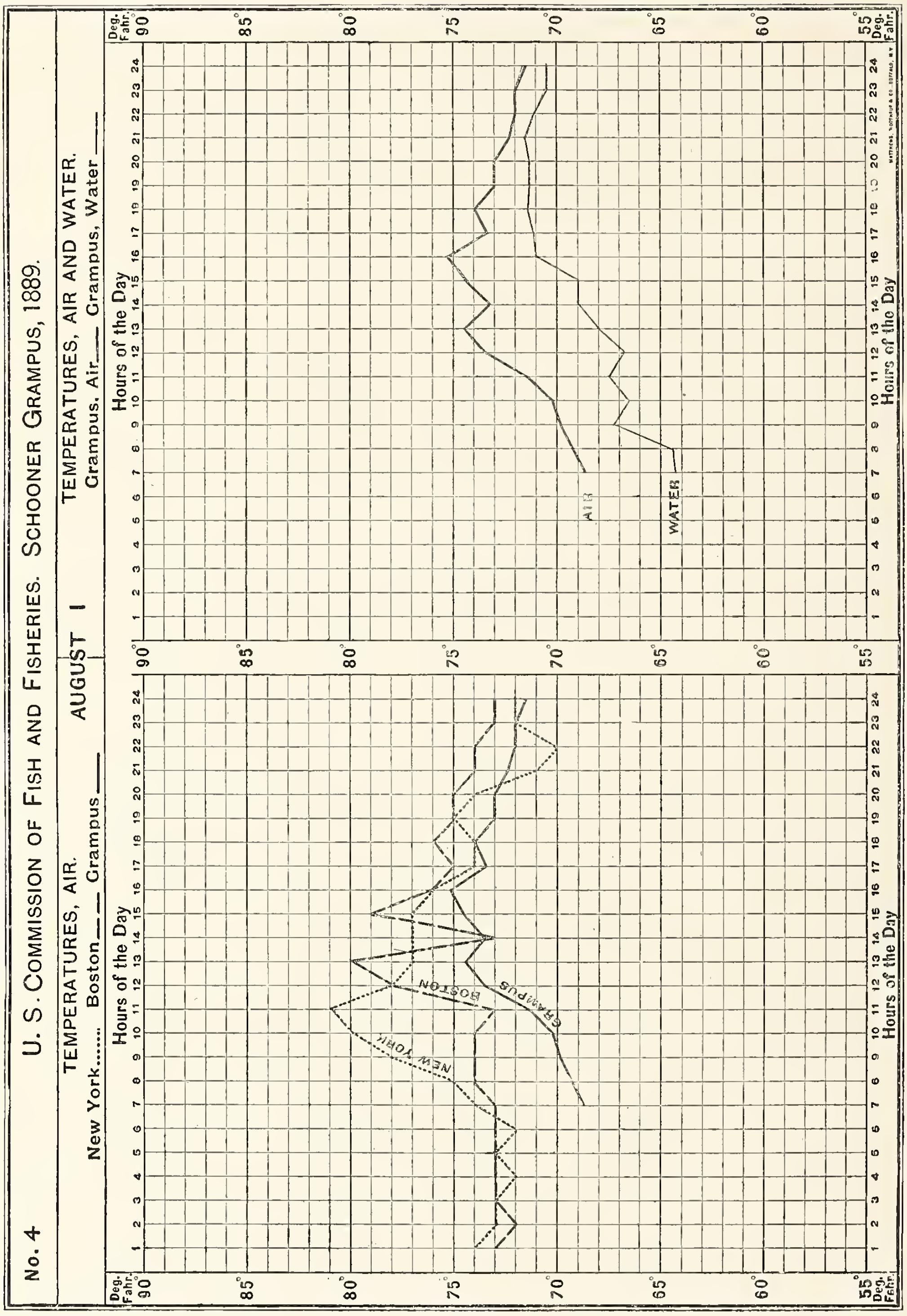

No. 4
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston—— Grampus——
AUGUST 1
TEMPERATURES, AIR AND WATER.
Grampus, Air—— Grampus, Water——
Hours of the Day
Deg. Fahr.
90° 85° 80° 75° 70° 65° 60° 55°
NEW YORK
BOSTON
GRAMPUS
AIR
WATER

Table 4.

Date, August 1, 1889. Solar radiation thermometer, 142° F. Maximum temperature, 80.9° F. Six's, 74.8° F.
Terrestrial radiation thermometer, 58° F. Minimum temperature, 61° F. Six's, 61.2° F.

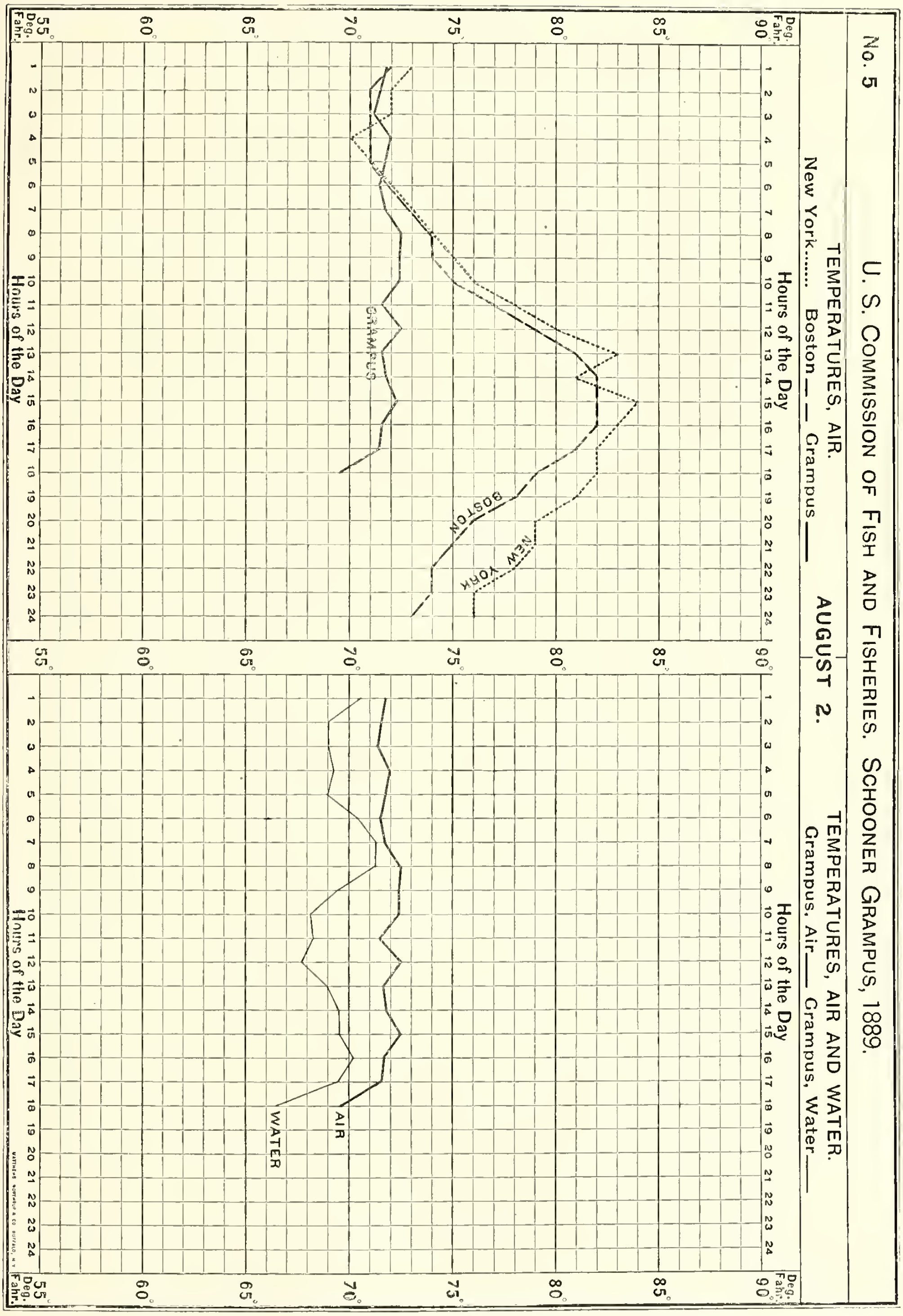
Station.	Position.	Hour.	Tide.	Temperature. Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Barometer. Reading.	t.	= 32°.	Clouds. 0—10.	Upper.	Lower.	Wind. Direction.	Force.	Rain.	State of sea.	Observer.
																		In.		
		5	L. 5-5	......	......	......	......	......	......	......	......	......	...	......	......	......	...	...	......	......
		6	......	......	......	......	......	......	......	......	......	......	...	......	......	......	...	...	......	......
		7	......	64.3	68.7	68.8	68.8	0.0	100.0	30.346	70.8	30.233	7	Cir. str.	Haze...	SSW.	5	...	Mod. sw.	Libbey.
F. 1, No. 21	41° 12′ 0″ N., 70′ 50″ 0′ W.	8	......	64.5	69.1	69.3	69.1	0.2	100.0	30.340	71.4	30.225	6	Cir. str.	Haze...	SSW.	4	...	...do....	Do.
		9	......	67.4	69.9	69.8	69.5	0.3	100.0	30.328	71.6	30.213	5	Cir.....	Haze...	SSW.	4	...	...do....	Do.
		10	H. 10-55	66.4	70.2	70.4	70.0	0.4	98.0	30.344	72.0	30.227	5	Cir.....	Haze..	SSW.	4	...	...do....	Do.
		11	......	67.4	71.5	72.0	70.9	1.1	95.0	30.338	73.4	30.219	6	Cir.....	Cu. str.	S. by W.	4	...	...do....	Do.
F. 2, No. 22	41° 2′ 0″ N., 70° 50′ 0″ W.	12	......	66.8	73.6	73.8	71.7	2.1	90.2	30.318	73.7	30.197	2	....	Cu. str.	S. by W.	4	...	...do...	Do.
		13	......	68.0	74.5	74.1	72.0	2.1	90.3	30.300	74.0	30.178	1	....	Cir.....	SSW.	5	...	...do...	Magie.
		14	......	69.0	73.3	73.3	71.9	1.4	92.5	30.274	74.3	30.152	3	....	Cir....	SSW.	5	...	...do....	Do.
F. 3, No. 23	40° 52′ 0″ N., 70° 50′ 0″ W.	15	......	69.0	74.5	74.5	73.0	1.5	92.7	30.278	75.0	30.153	4	Cir.....	Str.....	SSW.	3	...	...do....	Do.
		16	......	71.0	75.2	75.2	73.2	2.0	90.4	30..78	74.8	30.154	5	Cir.....	Str.....	SSW.	4	...	...do....	Do.
		17	L. 5-47	71.1	73.3	73.3	72.7	0.6	97.5	30.280	75.0	30.155	1	Cir.....	Str.....	SSW.	5	...	...do....	Rockwood.
F. 4, No. 24	40° 42′ 0″ N., 70° 50′ 0″ W.	18	......	71.4	74.0	74.0	73.1	0.9	96.0	30.280	75.0	30.155	1	Cir.....	Str.....	SSW.	5	...	...do....	Do.
		19	......	71.4	73.0	73.2	72.8	0.4	97.5	30.274	75.5	30.148	2	Cir.....	Str.....	SSW.	4	...	...do....	Do.
		20	......	71.3	73.0	73.0	72.8	0.2	100.0	30.260	75.5	30.134	1	Cir.....	Str.....	SSW.	5	...	...do....	Do.
F. 5, No. 25	40° 32′ 0″ N., 70° 50′ 0″ W.	21	......	71.5	72.4	73.0	72.8	0.2	100.0	30.275	75.0	30.150	1	Cir.....	Str.....	SSW.	4	...	...do....	Libbey.
		22	......	71.2	72.0	72.6	72.4	0.2	100.0	30.290	75.0	30.165	2	....	Str....	SSW.	4	...	...do....	Rockwood.
		23	H. 11-13	70.6	72.0	72.3	71.8	0.5	97.5	30.280	74.5	30.156	3	....	Str.....	SSW.	4	...	...do...	Do.
		24	......	70.5	71.7	72.0	71.2	0.8	96.0	30.290	75.0	30.165	3	....	Str.....	SSW.	4	...	...do....	Do.

TABLE 5.

Date, August 2, 1889. Solar radiation thermometer 138° F. Maximum temperature 74.6° F. Six's, 71.4° F.
Terrestrial radiation thermometer, 68° F. Minimum temperature, 70.9° F. Six's 71.8° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0-10.	Upper	Lower.	Direction.	Force.	In.		
F. 6, No. 26	40° 22′ 0″ N., 70° 50′ 0″ W.	1	....	70.4	71.8	72.0	71.8	0.2	100.0	30.240	74.5	30.116	10	....	Nimbus	SSW.	5	....	Mod. sw	Magie.
		2	....	69.0	71.6	71.8	71.4	0.4	97.0	30.242	74.0	30.120	10	....	Nimbus	SW. by S.	5	....	...do ...	Do.
		3	....	69.0	71.4	71.8	71.6	0.2	100.0	30.250	74.5	30.126	10	....	Nimbus	SW. by S.	5	....	...do ...	Do.
F. 7, No. 27	40° 12′ 0″ N., 70° 50′ 0″ W.	4	....	69.2	72.0	72.0	72.0	0.0	100.0	30.262	74.2	30.140	10	....	Nimbus	SW. by S.	4	....	...do ...	Do.
		5	L. 5-56	69.0	71.8	71.8	71.8	0.0	100.0	30.284	74.0	30.162	10	....	Nimbus	SW. by S.	4	....	...do ...	Rockwood.
		6	....	70.4	71.5	71.7	71.7	0.0	100.0	30.250	75.0	30.125	10	....	Nimbus	SSW.	4	(*)	...do ...	Do.
		7	....	71.3	71.7	72.0	72.0	0.0	100.0	30.244	75.0	30.119	10	....	Nimbus	SSW.	4	.21	.. do ...	Do.
		8	....	71.4	72.4	72.7	72.7	0.0	100.0	30.256	76.0	30.129	10	....	Nimbus	SSW.	4	....	...do ...	Do.
		9	....	69.5	72.3	72.4	72.3	0.1	100.0	30.234	76.0	30.107	10	....	Nimbus	SW.	5	....	...do ...	Magie.
		10	....	68.1	72.2	72.8	72.1	0.7	97.5	30.244	75.5	30.118	8	Cir ...	Str	SW.	6	....	...do ...	Do.
		11	H. 11-52	68.3	71.5	72.2	70.5	1.7	92.4	30.242	74.5	30.118	9	Cir ..	Str	SW. by S.	4	....	...do ...	Do
G. 1, No. 28	41° 12′ 0″ N., 71° 0′ 0″ W.	12	....	67.9	72.5	73.5	71.0	2.5	87.9	30.224	75.0	30.099	2	Cir ...	Str	SW. by S.	5	....	...do ...	Do.
		13	....	69.0	71.7	72.2	70.6	1.6	92.4	30.190	75.4	30.067	5	....	Cir. str	SW. by S.	5	....	...do ...	Rockwood.
H. 1, No. 29	41° 12′ 0″ N., 71° 10′ 0″ W.	14	....	69.6	71.8	72.0	70.9	1.1	94.9	30.188	75.0	30.063	7	....	Cir. str.	SW. by S.	5	....	...do ...	Do.
		15	....	69.5	72.4	72.1	71.6	0.5	97.5	30.180	74.5	30.056	10	Cir ..	Str	SW. by S.	6	....	...do ...	Do.
J. 1, No. 30	41° 12′ 0″ N., 71° 20′ 0″ W.	16	....	70.1	71.7	72.0	71.7	0.3	100.0	30.180	74.0	30.058	10	Cir ...	Str	SW. by S.	5	....	Choppy	Do.
		17	....	69.4	71.5	71.9	71.4	0.5	97.5	30.182	74.0	30.060	10	Cir ...	Str	SW. by S.	5	....	...do ...	Libbey.
K. 1, No. 31	41° 12′ 0″ N., 71° 30′ 0″ W.	18	L. 6-58	66.4	69.7	69.8	69.4	0.4	97.4	30.160	73.4	30.041	10	Cir ...	Str	SW. by S.	5	....	..do ...	Do.

* Rain.


No. 5
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston — — Grampus ——
AUGUST 2.
TEMPERATURES, AIR AND WATER.
Grampus. Air —— Grampus, Water ——
Hours of the Day
Deg. Fahr.
90°
85°
80°
75°
70°
65°
60°
55°
GRAMPUS
BOSTON
NEW YORK
AIR
WATER

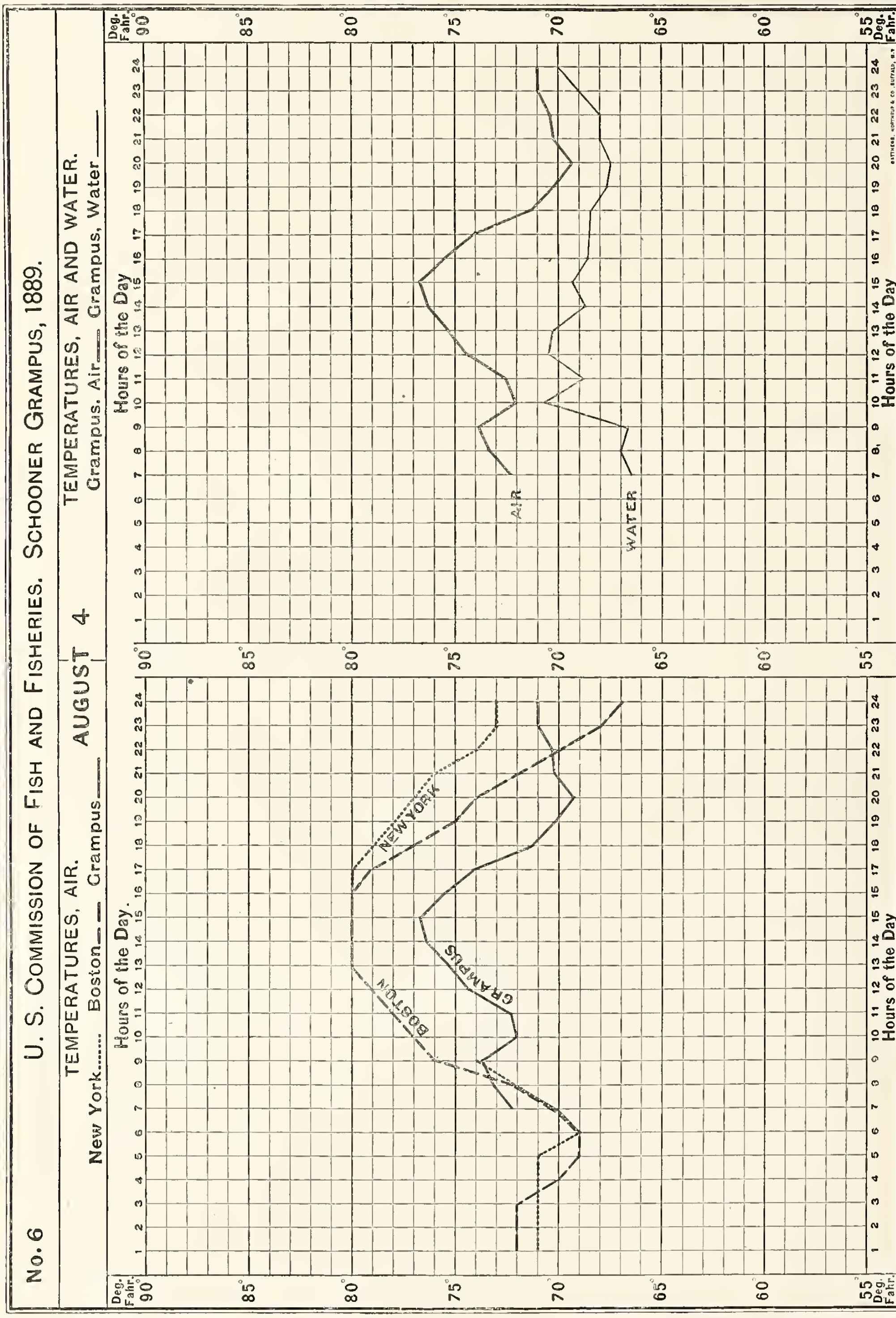

No. 6
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston— — Grampus——
AUGUST 4
TEMPERATURES, AIR AND WATER.
Grampus, Air—— Grampus, Water ——
Hours of the Day
Deg. Fahr.
90° 85° 80° 75° 70° 65° 60° 55°
NEW YORK
BOSTON
GRAMPUS
AIR
WATER

TABLE 6.

Date, August 4, 1889. Solar radiation thermometer, 138° F. Maximum temperature, 78° F. Six's, 76° F.
Terrestrial radiation thermometer, 65° F. Minimum temperature, 66° F. Six's, 66° F.

Station.	Position.	Hour.	Tide.	Temperature. Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Barometer. Reading.	t.	=32°.	Clouds. 0-10.	Upper.	Lower.	Wind. Direction.	Force.	Rain.	State of sea.	Observer.
																		In.		
		1	H. 1–32																	
		2																		
		3																		
		4																		
		5																		
		6																		
		7	L. 7–56	66.7	72.3	72.7	72.2	0.5	97.5	30.147	71.0	30.033	0			W.	2		Str. sw.	Rockwood.
K. 2, No. 32*	41° 2′ 0″ N., 71° 30′ 0″ W.	8		67.0	73.2	73.5	73.0	0.5	97.5	30.179	71.0	30.065	0			W.	1		...do	Do.
		9		66.8	73.9	74.0	73.5	0.5	97.5	30.185	71.5	30.069	0			W. by N.	1		...do	Do.
J. 2, No. 33	41° 2′ 0″ N., 71° 20′ 0″ W.	10		70.7	72.0	71.3	70.0	1.3	94.9	30.186	71.5	30.070	0			W. by N.	1		...do	Do.
		11		68.8	72.4	72.7	69.6	3.1	85.2	30.190	72.0	30.073	0			W. by N.	1		...do	Do.
H. 2, No. 34	41° 0′ 0″ N., 71° 10′ 0″ W.	12		70.4	74.6	74.6	69.0	5.6	74.4	30.186	73.0	30.067	0			W. by N.	1	†.50	...do	Do.
		13	H. 1–50	70.2	75.3	75.3	70.0	5.3	74.7	30.226	73.6	30.105	0			W. by N.	1		...do	Libbey.
G. 2, No. 35	41° 2′ 0″ N., 71° 0′ 0″ W.	14		68.8	76.3	76.0	70.6	5.4	74.7	30.226	74.3	30.104	0			W. by N.	1		...do	Do.
		15		69.2	76.8	77.0	70.3	6.7	70.8	30.230	74.8	30.106	0			W. by N.	1		...do	Do.
		16		68.7	75.7	75.8	69.3	6.5	70.4	30.230	74.3	30.108	0			W. by N.	1		Calmer	Do.
		17		68.5	74.1	73.8	69.0	4.8	78.6	30.224	73.4	30.105	0			W. by S.	3		...do	Magie.
E. 1, No. 36	41° 12′ 0″ N., 70° 40′ 0″ W.	18		68.5	71.2	71.2	67.8	3.4	82.4	30.228	73.0	30.109	0			W. by S.	3		Mod. sw.	Do.
		19		67.8	70.2	70.0	67.0	3.0	84.8	30.228	72.6	30.110	1		Str	W. by S.	4		...do	Do.
E. 2, No. 37	41° 2′ 0″ N., 70° 40′ 0″ W.	20		67.5	69.5	70.0	67.7	2.3	89.6	30.234	73.0	30.115	0			WSW.	3		...do	Do.
		21	L. 9–12	68.0	70.1	70.1	68.3	1.8	92.2	30.280	73.2	30.161	1		Str	WSW.	4		...do	Rockwood.
		22		68.0	70.3	70.5	69.0	1.5	92.3	30.282	73.0	30.163	6		Cu. str.	WSW.	2		...do	Do.
E. 3, No. 38	40° 52′ 0″ N., 70° 40′ 0″ W.	23		69.0	71.0	71.2	69.6	1.6	92.3	30.290	74.0	30.168	4		Cu. str.	WSW.	3		...do	Do.
		24		70.0	71.0	71.2	69.6	1.6	92.3	30.286	75.5	30.160	1		Cu. str.	WSW.	2		...do	Do.

* South of Block Island.

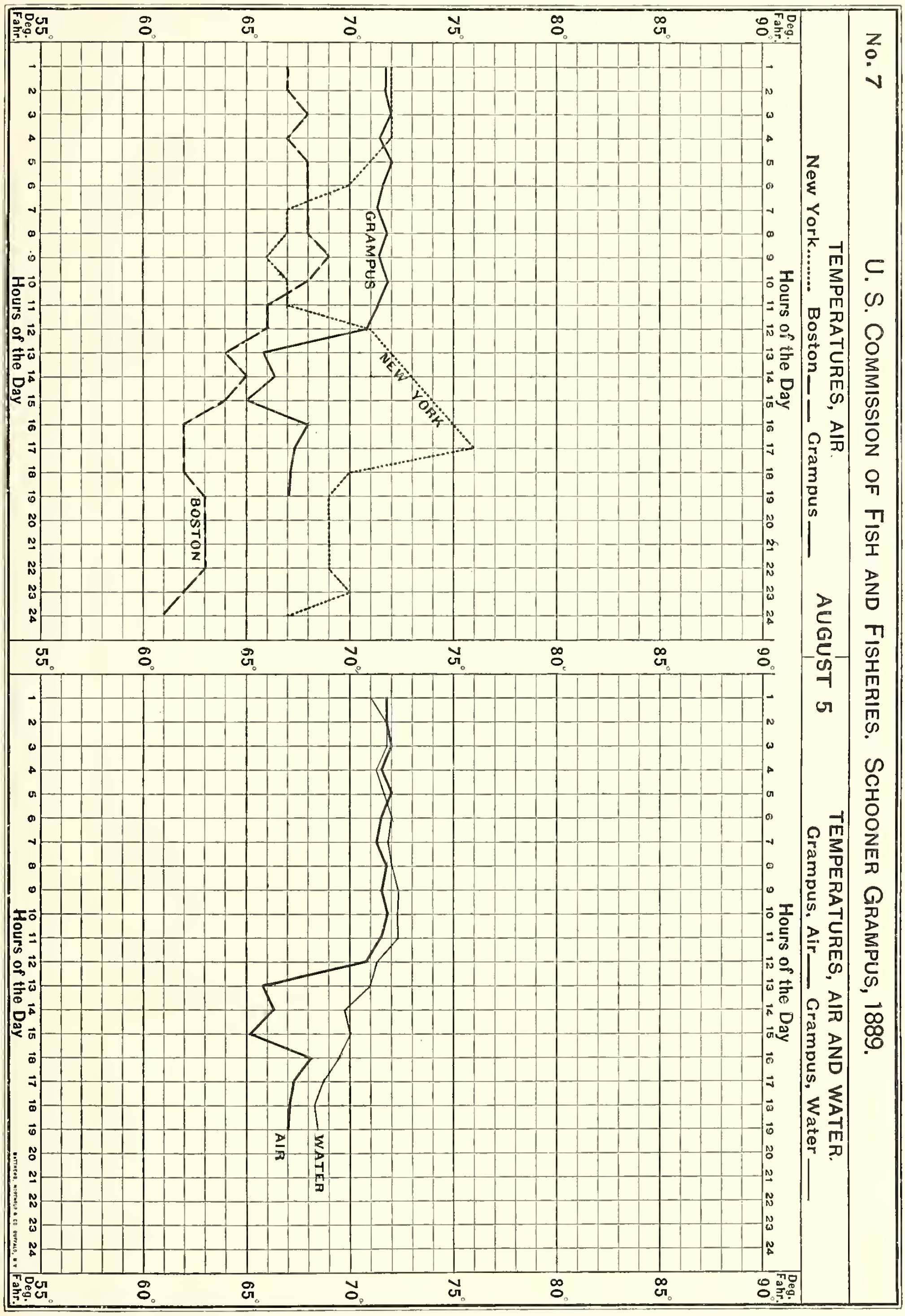
† Evaporation.

TABLE 7.

Date, August 5, 1889. Solar radiation thermometer, 138° F. Maximum temperature, 79° F. Six's, 80° F.
Terrestrial radiation thermometer, 54° F. Minimum temperature, 55° F. Six's, 57° F.

Station.	Position.	Hour.	Tide.	Temperature. Water.	Temperature. Air.	Temperature. Dry bulb.	Temperature. Wet bulb.	Temperature. Difference.	Temperature. Relative humidity.	Barometer. Reading.	Barometer. t.	Barometer. =32°.	Clouds. 0–10.	Clouds. Upper.	Clouds. Lower.	Wind. Direction.	Wind. Force.	Rain.	State of sea.	Observer.
																		In.		
		1	....	71.0	71.8	71.6	70.0	1.6	92.4	30.300	74.8	30.175	1	....	Haze ..	WSW.	3	....	Calm	Libbey.
		2	H. 2–48	71.8	71.8	72.0	70.2	1.8	92.4	30.286	74.6	30.163	2	....	Haze ..	SW.	3	....	...do	Do.
		3	....	71.9	72.0	72.0	70.0	2.0	90.0	30.270	74.5	30.148	2	....	Haze ..	SW.	2	....	...do	Do.
E. 4, No. 39	40° 42′ 0″ N., 70° 40′ 0″ W.	4	....	71.4	71.6	71.8	70.2	1.6	92.4	30.250	74.0	30.128	4	....	Str	SW.	4	....	...do	Do.
		5	....	71.6	72.1	72.1	71.2	0.9	95.0	30.280	74.7	30.156	4	....	Str	SW. by S.	2	....	...do	Magie.
		6	....	72.0	71.7	71.7	70.8	0.9	95.0	30.260	73.7	30.136	8	Cir ...	Str	SSW.	2	....	...do	Do.
		7	....	71.9	71.3	71.5	70.0	1.5	92.4	30.240	73.0	30.120	9	Cir ...	Str	S. by E.	3	....	...do	Do.
E. 5, No. 40	40° 32′ 0″ N., 70° 40′ 0″ W.	8	L. 8–53	72.1	71.8	71.8	70.5	1.3	94.9	30.190	74.0	30.068	10	Cir ...	Str	SSE.	4	....	...do	Do.
		9	....	72.3	71.5	71.8	70.3	1.5	92.4	30.170	74.5	30.047	10	....	Nimb ..	SE. by S.	5	(†)	...do	Rockwood.
F. 5, No. 41	40° 31′ 0″ N., 70° 50′ 0″ W.	10	....	72.2	71.7	71.7	71.6	0.1	100.0	30.122	73.5	30.002	10	....	Nimb ..	SE. by S.	5	(*)	Rising ...	Do.
		11	....	72.2	71.5	71.5	71.1	0.4	97.5	30.087	74.0	29.965	10	....	Nimb ..	S. by W.	6	(*)	...do	Do.
		12	....	71.3	70.9	70.8	70.0	0.8	94.9	30.068	75.1	29.943	10	....	Nimb ..	W.	5	(*)	Heavy sw	Do.
		13	....	71.0	65.8	65.8	65.0	0.8	97.2	30.100	70.5	29.988	10	....	Nimb ..	NE.	6	.51	...do	Magie.
		14	H. 2–49	69.9	66.2	66.2	65.0	1.2	94.5	30.112	66.5	30.002	10	....	Nimb ..	NNE.	5	....	...do	Do.
		15	....	70.0	65.0	.....	.....	...	......	30.080	70.0	29.969	10	....	Nimb ..	ENE.	1	....	.. do	Ship.
G. 3, No. 42	40° 52′ 0″ N., 71° 0′ 0″ W.	16	....	69.4	68.1	68.1	65.8	2.3	86.8	30.188	69.7	30.078	2	..... Cu. str		....	0	....	...do	Libbey.
		17	....	68.9	67.4	67.6	65.1	2.5	86.8	30.150	70.0	30.039	9	....	Cu. str .	N.	2	....	.. do	Rockwood.
		18	....	68.3	67.1	67.3	65.0	2.3	86.8	30.184	70.0	30.073	6	Cir ...	Cu. str .	NNW.	½	....	Mod. sw .	Do.
		19	....	68.4	67.0	66.8	64.8	2.0	89.1	30.200	70.4	30.088	8	Cir ...	Cu. str .	....	0	....	...do	Do.
		20	....	......	......	......	......	....	......	....	......	....	...	....	....	....	...	....	....	
		21	....	......	......	......	......	....	......	....	......	....	...	....	....	....	...	....	....	
		22	L. 10–9	... ..	......	......	......	....	....	....	......	....	...	....	....	....	...	....	....	

* Rain. † Evaporation, .42.


No. 7
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York....... Boston— — Grampus——
AUGUST 5
TEMPERATURES, AIR AND WATER.
Grampus, Air—— Grampus, Water——
Hours of the Day
Deg. Fahr.
GRAMPUS
NEW YORK
BOSTON
AIR
WATER

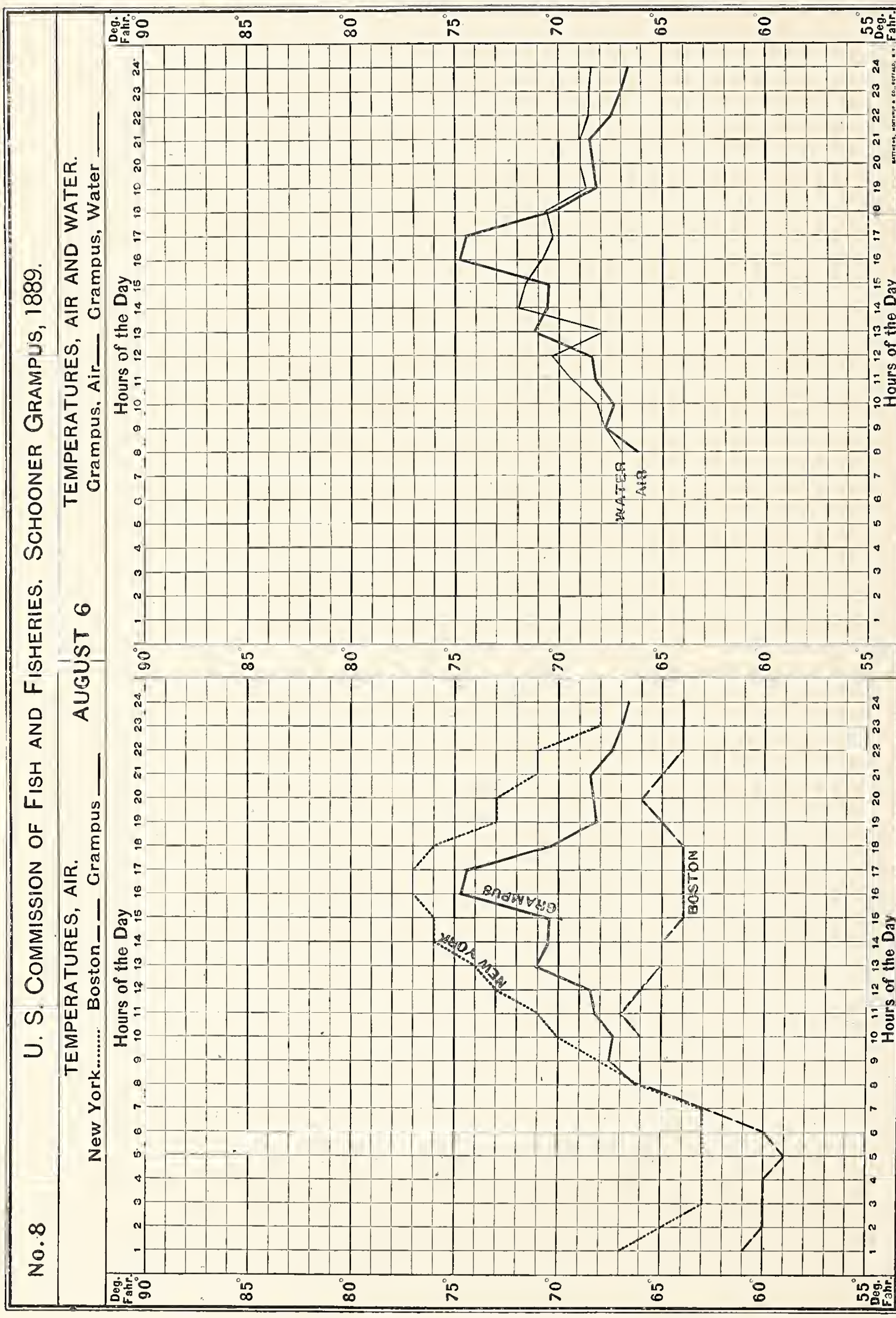

No. 8
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York....... Boston.___ Grampus___
AUGUST 6
TEMPERATURES, AIR AND WATER.
Grampus, Air___ Grampus, Water___
Hours of the Day
Deg. Fahr.
NEW YORK
GRAMPUS
BOSTON
WATER
AIR

TABLE 8.

Date, August 6, 1889. Solar radiation thermometer, 108.3° F. Maximum temperature, 72.6° F. Six's, 78° F.
Terrestrial radiation thermometer, 64° F. Minimum temperature, 64.2° F. Six's, 64° F.

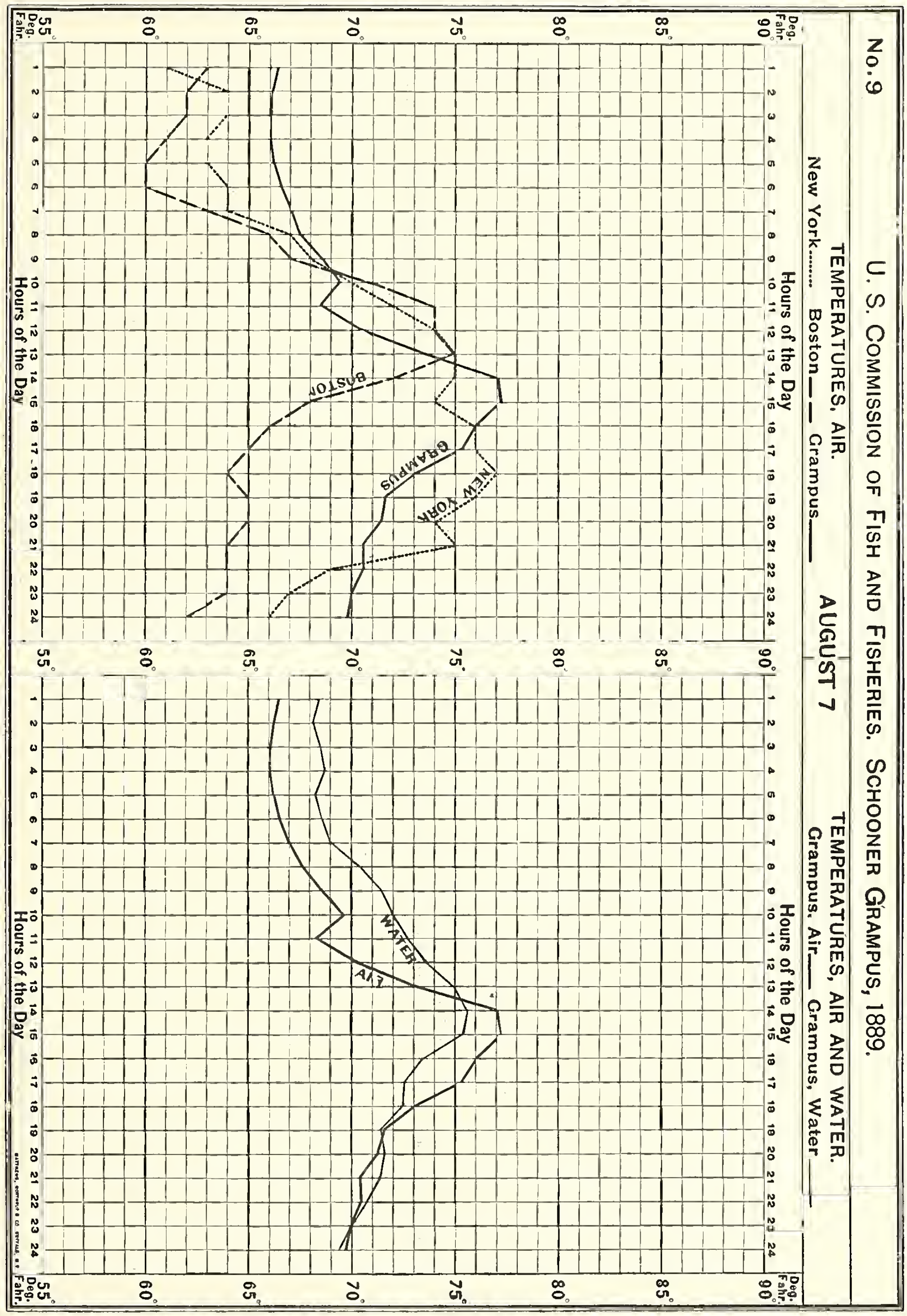
Station.	Position.	Hour.	Tide.	Temperature. Water.	Temperature. Air.	Temperature. Dry bulb.	Temperature. Wet bulb.	Temperature. Difference.	Temperature. Relative humidity.	Barometer. Reading.	Barometer. t.	Barometer. =32°.	Clouds. 0–10.	Clouds. Upper.	Clouds. Lower.	Wind. Direction.	Wind. Force.	Rain.	State of sea.	Observer.
																		In.		
		3	H. 3–38	......	......	......	......	......	......	......	......	......	...	......	......	......	...	...	......	
		4	......	......	......	......	......	......	......	......	......	......	...	......	......	......	...	...	......	
		5	......	......	......	......	......	......	......	......	......	......	...	......	......	......	...	...	......	
		6	......	......	......	......	......	......	......	......	......	......	...	......	......	......	...	...	......	
		7	......	......	......	......	......	......	......	......	......	......	...	......	......	......	...	...	......	
		8	......	67.0	66.1	66.0	63.8	2.2	89.0	30.292	69.5	30.182	9	Cir ...	Str	N.	1	....	Calm ...	Rockwood.
		9	L. 9–49	67.8	67.8	68.0	65.0	3.0	84.3	30.312	69.8	30.202	8	Cir ...	Str	N.	½	....	...do	Libbey.
		10	......	68.2	67.4	67.5	64.7	2.8	84.2	30.328	69.8	30.218	7	Cir ...	Str	NE.	½	....	...do	Do.
		11	......	69.4	68.3	68.4	65.2	3.2	84.3	30.309	70.0	30.198	4	Cir ..	Str	ENE.	1	....	...do	Do.
		12	......	70.4	68.4	68.7	65.2	3.5	81.9	30.292	70.4	30.180	4	Cir ...	Str	......	0	....	...do	Do.
		13	......	67.8	71.1	71.0	67.0	4.0	80.2	30.282	71.5	30.177	3	Cir ...	Cir	E.	½	....	...do	Magie.
		14	......	72.0	70.6	70.4	67.0	3.4	82.4	30.260	72.5	30.142	2	Str ...	Cir	SE.	½	....	...do	Do.
		15	H. 3–42	71.7	70.5	70.4	67.0	3.4	82.4	30.260	72.0	30.143	2	Cir ...	Cu.....	SE.	1	....	...do	Do.
		16	......	70.6	74.9	75.0	70.0	3.0	85.4	30.264	72.0	30.147	3	Cir ...	Cu.....	S. by W.	1	....	...do	Do.
		17	......	70.3	74.4	73.9	68.7	5.2	76.4	30.254	72.0	30.137	1	Cir ...	Cu.....	S.	2	....	...do	Rockwood.
D, 1, No. 43	41°12′0″ N., 70°30′0″ W.	18	......	70.5	70.1	69.9	66.9	3.0	84.8	30.230	72.0	30.113	1	Cir ...	Cu.....	S.	2	....	...do	Do.
		19	......	68.6	68.1	68.2	65.9	2.3	87.0	30.250	71.5	30.135	2	Cir ...	Str	S.	2	....	...do	Do.
		20	......	69.0	68.3	68.4	66.5	1.9	89.5	30.250	73.0	30.131	7	......	Str	S. by W.	2	....	...do	Do.
		21	......	69.0	68.4	68.6	66.4	2.2	89.6	30.260	72.0	30.143	8	......	Cu. str.	SSW.	1	....	...do	Libbey.
		22	......	68.7	67.4	67.5	65.0	2.5	86.8	30.252	71.4	30.137	4	......	Cu. str.	......	0	....	...do	Do.
		23	L. 11–1	68.6	67.0	67.3	65.3	2.0	89.3	30.240	70.8	30.127	5	......	Cu. str.	......	0	....	...do	Do.
		24	......	68.5	66.8	66.9	66.0	0.9	94.6	30.238	71.0	30.124	5	......	Cu. str.	......	0	....	...do	Do.

TABLE 9.

Date, August 7, 1889. Solar radiation thermometer, 141° F. Maximum temperature, 79.4° F. Six's, 79° F.
Terrestrial radiation thermometer, 63.3° F. Minimum temperature, 64.7° F. Six's, 65.5° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0–10.	Upper.	Lower.	Direction.	Force.			
																		In.		
		1	....	68.5	66.5	66.6	65.4	1.2	94.5	30.230	71.0	30.116	1	....	Str	....	0	....	Calm ...	Magie.
		2	....	68.1	66.2	66.4	65.0	1.4	91.9	30.218	72.0	30.101	1	....	Str	....	0	....	...do	Do.
		3	....	68.5	66.0	66.0	64.1	1.9	89.1	30.200	72.0	30.083	1	....	Str	....	0	....	...do	Do.
		4	H. 4–34	68.7	66.0	66.0	63.6	2.4	86.4	30.200	71.0	30.086	2	....	Str	WSW.	½	....	...do	Do.
		5	....	68.3	66.2	66.4	64.1	2.3	86.6	30.190	70.0	30.079	8	Cir....	Cu. str .	WSW.	½	....	...do	Rockwood.
		6	....	68.5	66.6	66.7	64.3	2.4	86.6	30.200	70.0	30.089	8	Cir ...	Cu. str .	W.	½	....	...do	Do.
		7	....	69.0	67.0	66.9	64.7	2.2	89.1	30.204	70.0	30.093	3	Cir ...	Cu. str .	W.	1	....	...do	Do.
		8	....	70.5	67.6	67.6	64.9	2.7	86.8	30.206	70.0	30.095	1	Cir ...	Cu. str .	W.	1	....	...do	Do.
D. 2, No. 44	41° 2′ 0″ N., 70° 30′ 0″ W.	9	....	71.5	68.5	68.7	65.3	3.4	81.9	30.212	70.7	30.099	2	Cir ...	Cu. str .	W.	1	*.42	...do	Libbey.
		10	L. 10–42	71.8	69.5	69.6	66.0	3.6	82.2	30.218	70.5	30.107	2	Cir ...	Cu. str .	W.	1	....	...do	Do.
		11	....	72.7	68.4	68.6	64.9	3.7	81.9	30.196	71.0	30.082	4	Cir ...	Cu. str .	....	0	....	...do	Do.
		12	....	73.5	70.3	70.4	65.9	4.5	77.6	30.216	71.5	30.100	5	Cir ...	Cu. str .	....	½	....	...do	Do.
D. 3, No. 45	40° 51′ 47″ N., 70° 30′ 0″ W.	13	....	75.0	73.2	73.3	67.3	6.0	71.6	30.210	73.0	30.091	3	Cir ...	Cu. str	....	¼	....	...do	Rockwood.
		14	....	75.5	77.0	77.0	68.0	9.0	60.8	30.186	75.0	30.061	5	Cir ...	Cu. str .	SW. by W.	1	....	...do	Do.
		15	....	75.3	77.1	77.0	66.8	10.2	56.3	30.174	75.5	36.048	2	Cir ...	Cu. str.	WSW.	2	....	...do	Do.
D. 4, No. 46	40° 42′ 0″ N., 70° 30′ 0″ W.	16	H. 4–35	73.5	76.0	76.0	66.0	10.0	56.3	30.166	75.0	30.041	3	Cir ...	Cu. str .	W.	3	....	...do	Do.
		17	....	72.7	75.3	75.4	66.0	9.4	58.0	30.172	74.8	30.048	3	Cir ...	Cu. str .	W.	3	....	...do	Libbey.
		18	....	72.6	73.1	73.2	64.9	8.3	61.5	30.172	74.6	30.048	3	Cir ...	Cu. str .	W.	3	....	...do	Do.
D. 5, No. 47	40° 32′ 0″ N., 70° 30′ 0″ W.	19	....	71.3	71.6	71.6	65.4	6.2	70.8	30.188	74.8	30.064	1	....	Str	W. by N.	2	....	...do	Do.
		20	....	71.6	71.4	71.5	66.4	5.1	75.4	30.208	74.0	30.086	1	....	Str	W. by N.	2	....	...do	Do.
D. 6, No. 48	40° 22′ 0″ N., 70° 30′ 0″ W.	21	....	71.5	70.5	70.8	66.2	4.6	77.6	30.216	73.5	30.096	0	....	....	W. by S.	2	....	...do	Magie.
		22	....	70.9	70.6	70.6	66.2	4.4	77.6	30.224	73.5	30 104	0	....	....	WSW.	2	....	...do	Do.
D. 7, No. 49	40° 12′ 0″ N., 70° 30′ 0″ W.	23	......	70.0	70.0	70.0	65.5	4.5	77.4	30.222	73.5	30.102	0	....	....	WSW.	2	....	.. do	Do.
		24	L. 11–49	69.5	69.8	69.8	66.0	3.8	79.9	30.222	73.0	30.103	0	....	....	WSW.	2	....	...do	Do.

* Evaporation.


No. 9
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston—— Grampus——
AUGUST 7
TEMPERATURES, AIR AND WATER.
Grampus, Air—— Grampus, Water——
Hours of the Day
Deg. Fahr.
BOSTON
GRAMPUS
NEW YORK
WATER
AIR

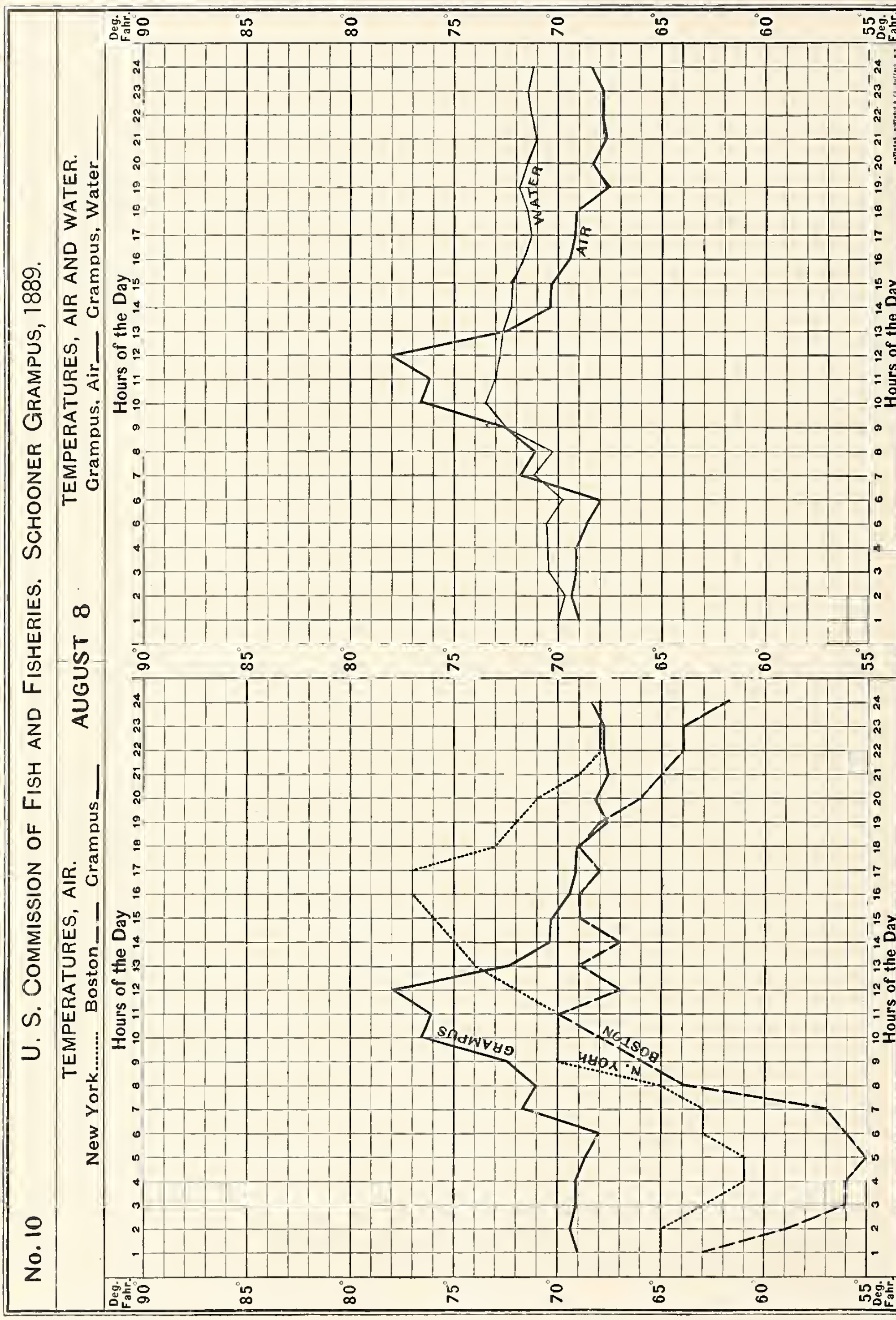

No. 10
U. S. Commission of Fish and Fisheries. Schooner Grampus, 1889.
Temperatures, Air.
New York....... Boston.___ Grampus___
August 8
Temperatures, Air and Water.
Grampus, Air___ Grampus, Water___
Hours of the Day
Deg. Fahr.
Grampus
N. York
Boston
Water
Air

TABLE 10.

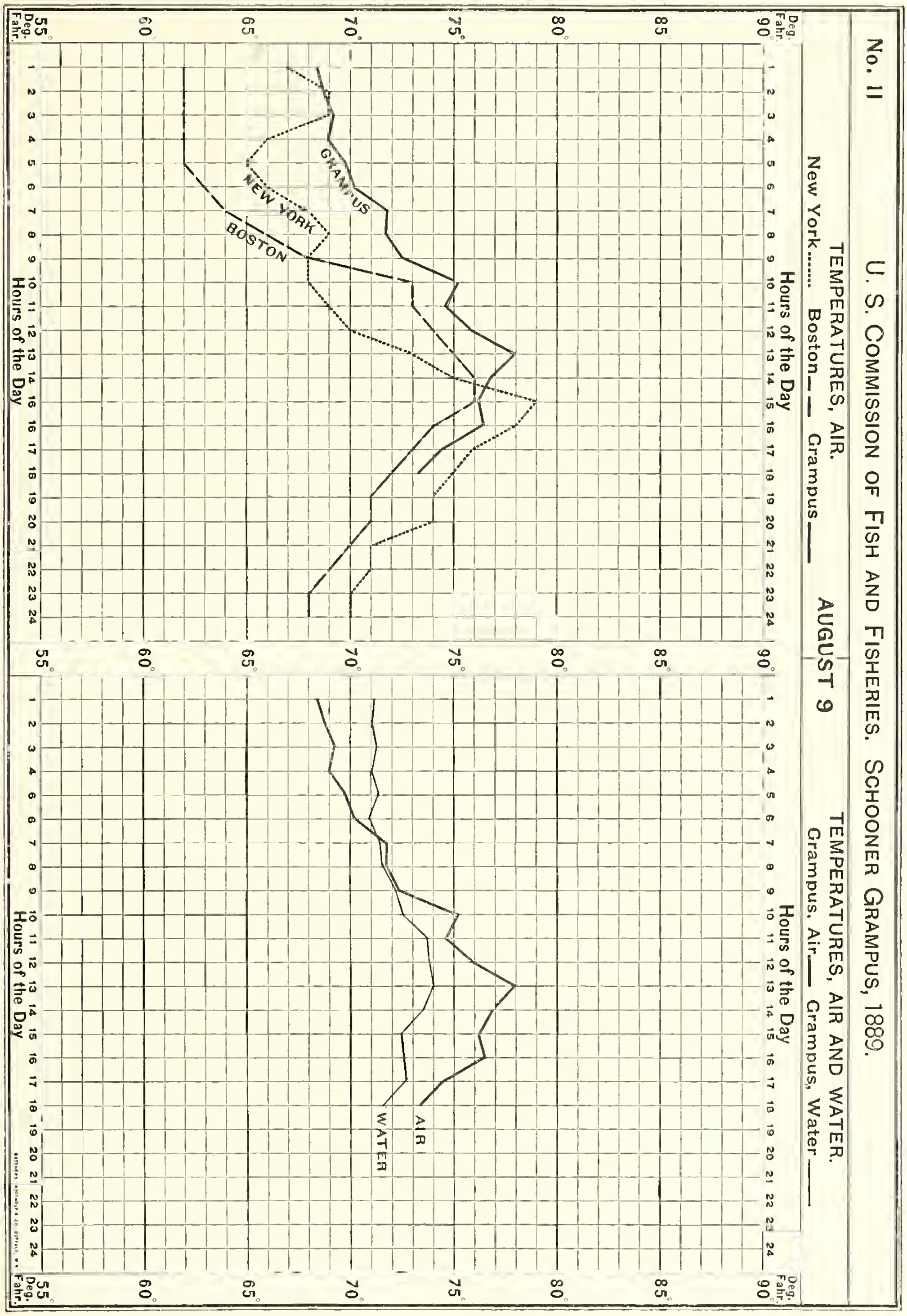
Date, August 8, 1889. Solar radiation thermometer, 125.4° F. Maximum temperature, 79.8° F. Six's, 79.2° F.
Terrestrial radiation thermometer, 66.2° F. Minimum temperature, 66.4° F. Six's, 67° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0—10.	Upper.	Lower.	Direction.	Force.	In.		
		1	....	70.0	69.0	69.2	65.0	4.2	79.6	30.228	73.0	30.109	½	....	Cum..	SSW.	1	....	Calm....	Rockwood.
		2	....	69.7	69.4	69.8	65.1	4.7	77.3	30.224	73.0	30.105	½	....	Cum..	....	0	....	...do....	Do.
		3	....	70.4	69.3	69.4	65.4	4.0	79.6	30.230	72.5	30.112	½	....	Str....	....	0	....	...do....	Do.
		4	....	70.5	69.3	69.4	66.3	3.1	84.6	30.228	72.5	30.110	½	....	Str....	N. by E.	1	....	...do....	Do.
		5	H. 5–25	70.5	68.8	68.0	67.8	0.2	100.0	30.240	72.3	30.123	1	....	Str....	NE.	1	....	...do....	Libbey.
		6	....	69.9	68.0	68.0	66.2	1.8	89.4	30.246	71.8	30.130	½	....	Str....	NE.	1	....	...do....	Do.
D. 8, No. 50	40° 2′ 0″ N., 70° 30′ 0″ W.	7	....	71.1	71.8	71.4	65.7	5.7	72.9	30.254	71.9	30.138	⅛	....	Str....	NE. by N.	3	....	...do....	Do.
		8	....	70.3	71.0	71.2	64.5	6.7	68.3	30.258	72.0	30.141	½	....	Str....	NE. by N.	3	....	...do....	Do.
D.10, No.51	39° 49′ 0″ N., 70° 30′ 0″ W.	9	....	72.3	72.3	72.6	66.2	6.4	69.2	30.272	72.0	30.155	¼	....	Cum..	NNE.	3	....	...do....	Magie.
		10	....	73.4	76.7	76.8	69.5	7.3	66.6	30.290	74.0	30.168	¼	....	Cum..	NNE.	4	....	...do....	Do.
		11	L. 11–33	73.0	76.2	76.2	69.0	7.2	68.5	30.292	74.6	30.168	¼	....	Cum..	NE.	3	....	...do....	Do.
		12	....	72.9	78.0	77.9	69.5	8.4	63.0	30.282	74.5	30.159	0	....	....	NE.	2	....	...do....	Do.
		13	....	72.6	72.3	72.1	66.1	6.0	71.2	30.300	73.7	30.179	0	....	....	NE.	3	....	...do....	Libbey.
		14	....	72.3	70.3	70.3	64.5	5.8	72.5	30.284	72.8	30.166	0	....	Haze..	NE.	3	....	...do....	Do.
D.10, No.52	39° 42′ 0″ N., 70° 30′ 0″ W.	15	....	72.2	70.2	70.1	63.5	6.6	67.8	30.282	73.0	30.163	0	....	Haze..	NE.	1	....	...do....	Do.
		16	....	71.7	69.5	69.5	64.0	5.5	72.5	30.276	72.8	30.158	0	....	Haze..	NE.	1	....	...do....	Do.
		17	H. 5–26	71.5	69.2	69.2	63.0	6.2	70.0	30.302	73.0	30.183	0	....	Haze..	NE.	1	....	...do....	Magie.
		18	....	71.6	69.1	69.0	63.5	5.5	72.1	30.304	73.0	30.184	0	....	Haze .	NE.	1	....	...do....	Do.
		19	....	71.9	67.7	67.7	62.2	5.5	71.7	30.304	72.5	30.185	¼	....	Cum..	ENE.	1	....	...do....	Do.
		20	....	71.6	68.2	68.2	63.8	4.4	76.6	30.332	72.0	30.213	0	....	....	E. by S.	1	....	...do....	Do.
		21	....	71.0	67.7	68.0	64.0	4.0	79.3	30.350	72.5	30.230	½	....	Cum..	E.	1	....	...do....	Rockwood.
		22	....	71.3	67.9	68.0	64.0	4.0	79.3	30.330	72.5	30.210	1	....	Cum..	SE.	2	....	...do....	Do.
D 11, No.53	39° 32′ 0″ N., 70° 30′ 0″ W.	23	....	71.4	67.9	68.0	64.0	4.0	79.3	30.332	72.0	30.213	½	....	Cum..	SE.	1	....	...do....	Do.
		24	....	71.2	68.3	68.5	64.0	4.5	77.0	30.340	72.0	30.221	0	....	Cum..	S. by W.	3	....	...do....	Do.

TABLE 11.

Date, August 9, 1889. Solar radiation thermometer, 122.9° F. Maximum temperature, 84° F. Six's 78.6° F.
Terrestrial radiation thermometer, 65.2° F. Minimum temperature, 66.2° F. Six's 68° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0—10.	Upper.	Lower.	Direction.	Force.			
																		In.		
		1	L. 0-35	71.1	68.5	68.8	63.5	5.3	72.1	30.326	71.7	30.204	½	....	Cum ..	S. by W.	3	....	Calm ...	Libbey.
		2	....	71.0	68.8	68.9	64.0	4.9	74.7	30.315	71.0	30.201	¼	....	Str...	SSW.	3	....	...do ...	Do.
D. 12, No. 54	39° 22′ 0″ N., 70° 30′ 0″ W.	3	....	71.3	69.2	69.4	64.2	5.2	74.7	30.320	71.0	30.206	½	....	Str....	SSW.	3	....	...do	Do.
		4	....	71.0	69.0	69.5	65.5	4.0	79.6	30.308	72.0	30.189	½	....	Str...	SSW.	2	....	...do	Do.
		5	....	71.3	69.7	69.8	66.0	3.8	79.9	30.332	72.0	30.213	1	Cir....	Str....	SSW.	2	....	...do	Magie.
		6	H. 6-13	70.9	70.1	70.2	66.9	3.3	82.4	30.334	72.0	30.215	2	Cir....	Str....	S. by W.	2	....	...do	Do.
		7	....	71.4	71.8	71.9	67.0	4.9	75.8	30.336	73.5	30.213	4	Cir....	Str....	W. by S.	3	....	...do	Do.
D. 13, No. 55	39° 12′ 0″ N., 70° 32′ 0″ W.	8	....	71.6	71.8	71.9	66.3	5.6	73.3	30.346	72.8	30.226	4	Cir....	Str....	W. by S.	3	....	...do	Do.
		9	....	72.2	72.4	72.5	67.0	5.5	73.7	30.332	73.5	30.210	4	Cir....	Str....	WSW.	3	....	...do	Rockwood.
		10	....	72.4	75.2	75.0	68.5	6.5	70.2	30.340	74.5	30.215	4	Cir ...	Str....	WSW.	4	....	...do	Do.
E. 13, No. 56	39° 14′ 0″ N., 70° 40′ 0″ W.	11	....	73.7	74.7	75.0	70.0	5.0	76.8	30.340	75.0	30.213	5	Cir....	Str....	WSW.	4	....	...do	Do.
		12	L. 12-24	73.8	75.8	75.7	70.0	5.7	74.7	30.336	75.0	30.209	4	Cir....	Str....	WSW.	4	....	...do	Do.
E. 12, No. 57	39° 24′ 0″ N., 70° 40′ 0″ W.	13	....	74.0	78.0	78.0	70.4	7.6	67.1	30.322	77.0	30.190	7	Cir....	Str....	W. by S.	4	....	...do	Magie.
		14	....	73.5	76.8	78.8	69.9	8.9	61.8	30.328	76.5	30.198	8	Cir....	Str....	W. by S.	4	....	...do ...	Do.
		15	....	72.5	76.2	76.2	70.2	6.0	72.7	30.266	77.0	30.136	6	Cir....	Str....	W. by S.	4	....	Mod. sw.	Do.
E. 11, No. 58	39° 34′ 0″ N., 70° 40′ 0″ W.	16	....	72.6	76.5	76.5	70.2	6.3	70.8	30.272	76.5	30.144	5	Cir....	Str....	WSW.	4	....	Choppy .	Do.
		17	....	72.7	74.5	74.5	69.3	5.2	76.4	30.264	76.0	30.137	6	Cir....	Str....	WSW.	4	....	...do	Rockwood.
		18	H. 6-15	71.5	73.2	73.0	68.7	4.3	78.3	30.250	76.0	30.123	6	....	Cu.str.	WSW.	5	....	...do	Do.


No. II
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston— — Grampus——
AUGUST 9
TEMPERATURES, AIR AND WATER.
Grampus. Air—— Grampus, Water——
Hours of the Day
Deg. Fahr.
GRAMPUS
NEW YORK
BOSTON
AIR
WATER

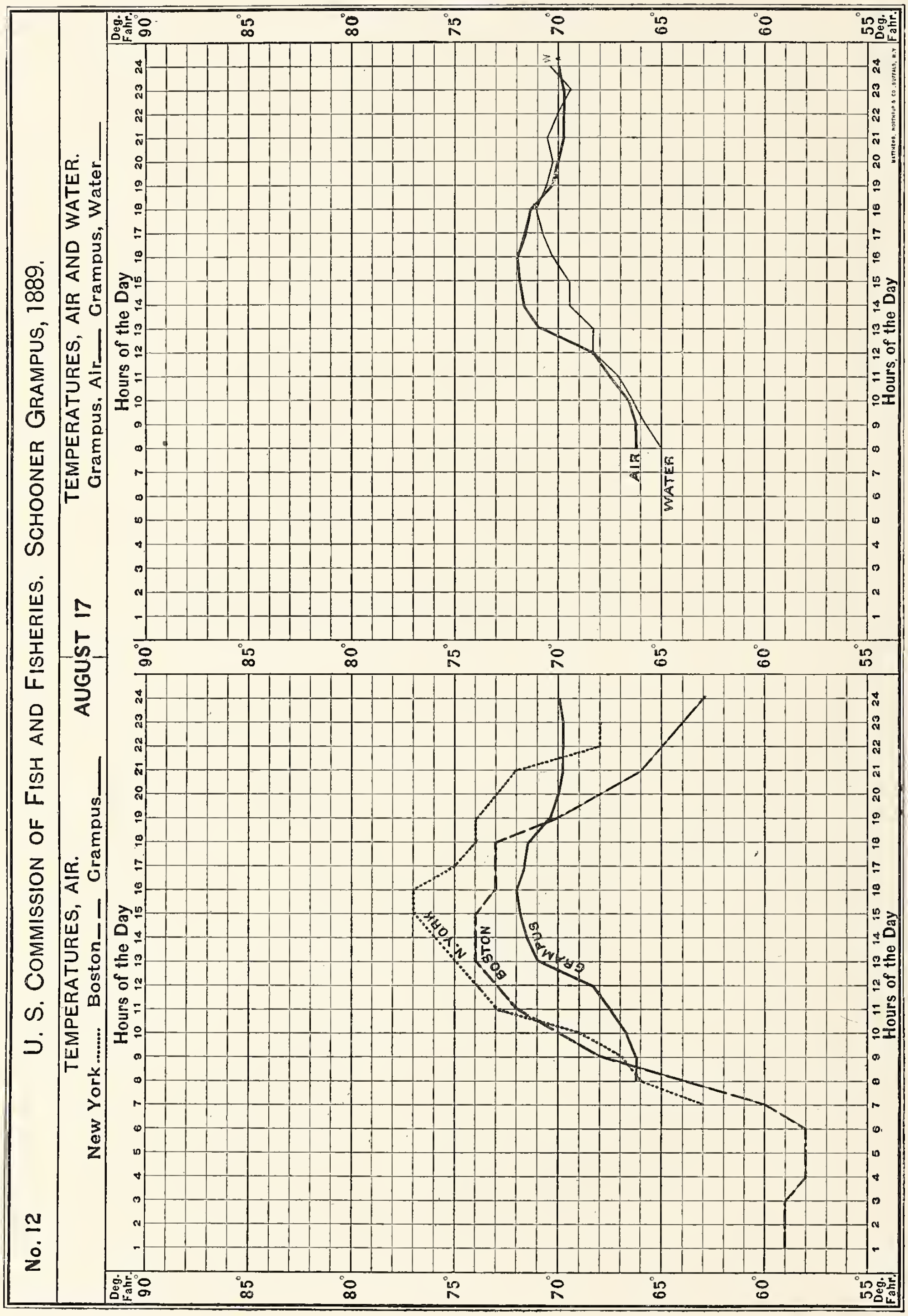

No. 12
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York .... Boston — — Grampus —
AUGUST 17
TEMPERATURES, AIR AND WATER.
Grampus, Air — Grampus, Water —
Hours of the Day
Deg. Fahr.
N. YORK
BOSTON
GRAMPUS
AIR
WATER

TABLE 12.

Date, August 17, 1889. Solar radiation thermometer, 135.3° F. Maximum temperature, 77° F. Six's, 75° F.
Terrestrial radiation thermometer, 60.3° F. Minimum temperature, 61.7° F. Six's, 61.2° F.

Station.	Position.	Hour.	Tide.	Temperature. Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Barometer. Reading.	t.	=32°.	Clouds. 0–10.	Upper.	Lower.	Wind. Direction.	Force.	Rain.	State of sea.	Observer.
																		In.		
		1	H. 0-40																	
		2																		
		3																		
		4																		
		5																		
		6																		
		7	L. 7-3																	
		8		65.0	66.2	66.2	65.1	1.1	94.5	30.090	69.0	29.981	1		Str	W. by S.	2		Calm	Rockwood.
		9		65.9	66.3	66.8	64.5	2.3	86.7	30.102	69.0	29.993	3	Cir	Str	W.	2		do	Libbey.
		10		66.4	66.7	62.0	63.8	3.2	83.9	30.118	69.4	30.008	3	Cir	Str	W. by S.	2		do	Do.
		11		67.2	67.5	68.0	64.0	4.0	79.3	30.120	71.0	30.006	3	Cir	Str	W. by S.	3		do	Do.
G. 2, No. 59	41° 2′ 0″ N., 71° 0′ 0″ W.	12	H. 12-54	68.2	68.2	68.8	64.5	4.3	79.5	30.112	70.4	30.000	4	Cir	Str	W. by S.	3		do	Do.
		13		68.2	71.0	71.0	66.0	5.0	75.4	30.102	71.2	29.998	6	Cir	Str	W. by S.	3		do	Magie.
G. 3, No. 60	40° 52′ 0″ N., 71° 0′ 0″ W.	14		69.5	71.6	71.7	67.0	4.7	75.8	30.086	71.3	29.971	3	Cir	Str	W. by S.	3		do	Do.
		15		69.5	71.9	72.0	67.0	5.0	75.8	30.094	72.0	29.977	2	Cir	Str	W. by S.	3		do	Do.
G. 4, No. 61	40° 42′ 0″ N., 71° 3′ 0″ W.	16		70.2	72.0	72.0	66.5	5.5	73.5	30.094	72.0	29.977	2	Cir	Str	W. by S.	4		do	Do.
		17		70.8	71.8	71.8	66.8	5.0	75.6	30.123	73.0	30.004	4	Cir	Str	W.	4		Mod. sw.	Rockwood.
G. 5, No. 62 (*)	40° 32′ 0″ N., 71° 0′ 0″ W.	18		71.2	71.4	71.4	66.0	5.4	73.3	30.125	72.5	30.007	3	Cir	Str	W.	2		do	Do.
		19		70.4	70.3	70.3	65.2	5.1	75.1	30.120	72.5	30.002	2	Cir	Str	W.	2		do	Do.
G. 6, No. 63	40° 22′ 0″ N., 71° 0′ 0″ W.	20	L. 8-12	70.2	70.0	70.0	65.5	4.5	77.5	30.150	72.5	30.032	1		Str	W.	2		do	Do.
		21		70.4	69.8	70.0	66.0	4.0	79.9	30.142	72.3	30.024	1		Str	W.	3		do	Libbey.
G. 7, No. 64	40° 12′ 0″ N., 71° 0′ 0″ W.	22		70.0	69.8	70.0	66.0	4.0	79.9	30.140	72.3	30.022	1		Str	W.	3		do	Do.
		23		69.6	69.8	69.8	65.8	4.0	79.9	30.150	72.3	30.032	1		Str	WNW.	3		do	Do.
G. 8, No. 65	40° 2′ 0″ N., 71° 0′ 0″ W.	24		70.3	70.0	70.1	66.2	3.9	80.0	30.140	73.0	30.021	0			WNW.	3		do	Do.

* Surface thermometer 6812 was used from this point on.

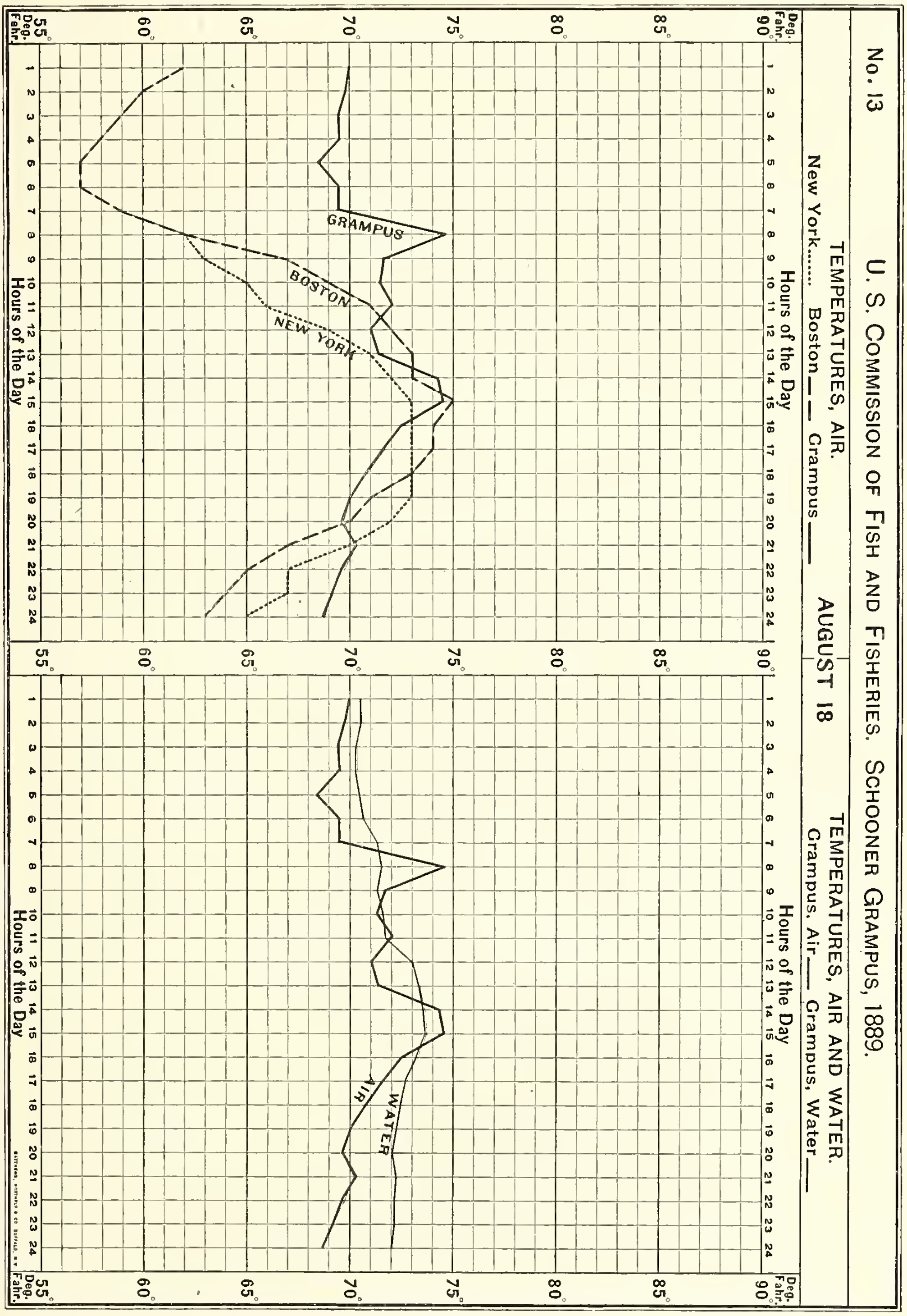
TABLE 13.

Date, August 18, 1889. Solar radiation thermometer, 133° F. Maximum temperature, 76.3° F. Six's, 77° F.
Terrestrial radiation thermometer, 66.2° F. Minimum temperature, 65.5° F. Six's, 64.5° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	= 32°.	0–10.	Upper.	Lower.	Direction.	Force.	In.		
		1	H. 1–48	70 6	70.0	70.0	66.6	3.4	82.2	30.102	72.6	29.984	0			WNW.	4		Calm	Magie.
		2		70.6	69.8	69.8	66.6	3.2	84.6	30.138	73.0	30.019	0			WNW.	3		do	Do.
G. 9, No. 66	39° 52′ 0″ N., 71° 0′ 0″ W.	3		70.4	69.5	69.5	66.5	3.0	84.7	30.128	72.4	30.011	0			NW. by N.	3		do	Do.
		4		70.3	69.6	69.6	67.0	2.6	87.2	30.128	72.5	30.010	1	Cir	Str	NW. by N.	3		do	Do.
		5		70.5	68.5	68.5	66.0	2.5	87.0	30.170	72.5	30.052	2		Str	NW. by N.	2		do	Rockwood.
		6		70.6	69.6	69.7	65.7	4.0	79.7	30.170	72.0	30.053	1		Str	NW. by N.	1		do	Do.
		7		71.3	69.5	69.5	66.0	3.5	82.2	30.170	72.5	30.052	1		Str	NNW.	1		do	Do.
F. 10, No. 67	39° 42′ 0″ N., 70° 54′ 0″ W.	*8	L. 8–4	71.5	74.6	74.5	69.0	5.5	74.4	30.176	73.0	30.057	½		Str	NNW.	1	†.50	do	Do.
		9		71.4	71.8	71.9	67.0	4.9	75.7	30.200	72.0	30.083	0			N.	1		do	Libbey.
		10		71.6	71.5	71.7	66.8	4.9	75.5	30.200	72.0	30.083	3	Str	Str	N.	1		do	Do.
		11		71.8	72.0	72.0	67.0	5.0	75.8	30.192	72.0	30.075	5	Str	Str	N.	1		do	Do.
F. 11, No. 68	39° 30′ 0″ N., 70° 58′ 0″ W.	12		73.0	71.0	71.0	65.8	5.2	75.2	30.190	73.0	30.071	2		Str	N.	1		do	Do.
		13	H. 1–50	73.2	71.3	71.0	65.6	5.4	73.0	30.184	74.0	30.062	2		Str	NNW.	1		do	Rockwood.
		14		73.4	74.3	74.0	67.5	7.0	67.7	30.180	75.5	30.055	6		Str	NW.	1		do	Do.
		15		73.6	74.5	74.0	67.5	6.5	69.8	30.174	75.5	30.049	8		Str	NW. by W.	2		do	Do.
G. 12, No. 69	39° 22′ 0″ N., 71° 4′ 0″ W.	16		73.2	72.5	72.0	66.7	5.3	73.5	30.188	74.0	30.066	9		Str	NW. by W.	1		Mod. sw.	Do.
		17		72.8	71.7	71.8	66.7	5.1	75.5	30.184	74.5	30.061	9	Str	Cum	NW. by W.	2		do	Libbey.
		18		72.5	70.8	70.8	66.0	3.8	80.0	30.192	74.0	30.070	6	Str	Cum	NW. by W.	2		do	Do.
		19		72.2	70.0	70.1	66.0	4.1	79.9	30.200	73.0	30.081	2		Cum	NNW.	2		do	Do.
H. 13, No. 70	39° 12′ 0″ N., 71° 9′ 30″ W.	20		72.0	69.8	70.0	65.7	4.3	77.4	30.220	73.8	30.099	6		Str	NW. by N.	2		do	Do.
		21	L. 9–18	72.2	70.1	70.1	66.3	3.8	79.9	30.222	73.0	30.102	1		Str	NNW.	2		do	Magie.
		22		72.2	69.7	69.8	65.5	4.3	77.5	30.216	73.0	30.097	2		Str		0		do	Do.
		23		72.2	69.2	69.2	65.0	4.2	79.6	30.216	73.0	30.097	1		Str		0		do	Do.
		24		72.0	68.8	68.8	65.3	3.5	81.9	30.214	73.0	30.095	1		Str		0		do	Do.

* Sun on thermometer box.

† Evaporation.


No. 13
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston— — Grampus——
AUGUST 18
TEMPERATURES, AIR AND WATER.
Grampus, Air—— Grampus, Water——
Hours of the Day
Deg. Fahr.
GRAMPUS
BOSTON
NEW YORK
AIR
WATER

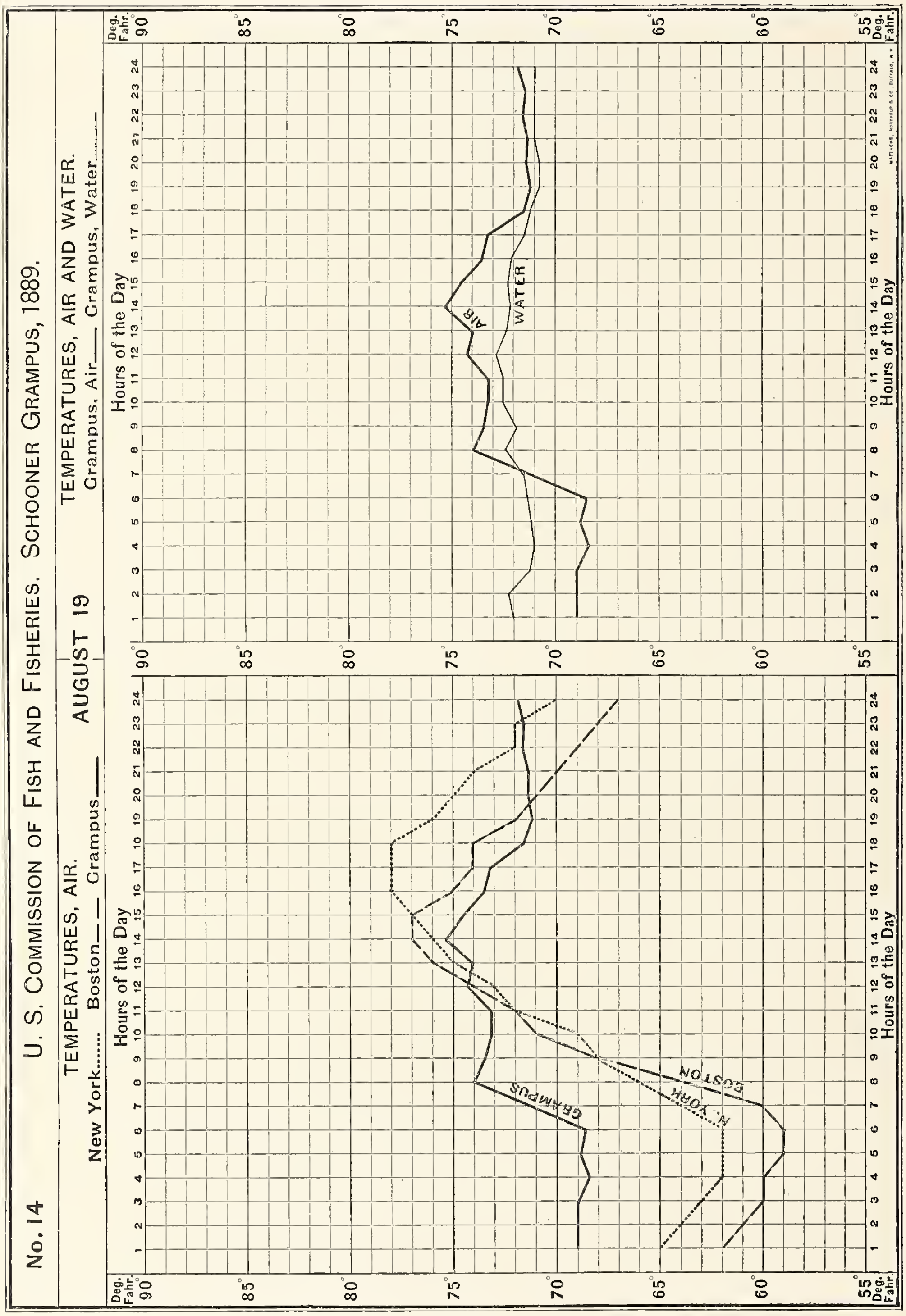

No. 14
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston.—— —— Grampus.——
AUGUST 19
TEMPERATURES, AIR AND WATER.
Grampus, Air—— Grampus, Water——
Hours of the Day
Deg. Fahr.
GRAMPUS
BOSTON
N. YORK
AIR
WATER

TABLE 14.

Date, August 19, 1889. Solar radiation thermometer, 131.3° F. Maximum temperature, 78.9° F. Six's, 77° F.
Terrestrial radiation thermometer, 65.7° F. Minimum temperature, 67.8° F. Six's, 69° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0—10.	Upper.	Lower.	Direction.	Force.			
																		In.		
		1	....	72.0	69.0	69.0	65.5	3.5	84.3	30.206	72.5	30.089	1	....	Str.....	NW.	½	....	Calm...	Rockwood.
		2	H. 2–50	72.2	69.0	69.3	64.8	4.5	77.0	30.220	72.0	30.103	1	....	Cum ...	NW. by W.	2	....	...do ...	Do.
		3	....	71.3	69.0	69.2	65.0	4.2	79.6	30.216	72.0	30.099	½	....	Cum ...	NW. by W.	2	....	...do ...	Do.
J.13, No. 71	39° 12′ 0″ N., 71° 20′ 0″ W.	4	...	71.0	68.6	68.8	64.8	4.0	79.5	30.220	71.5	30.085	½	....	Cum ...	NW. by W.	2	....	...do ...	Do.
		5	....	71.2	68.9	69.0	65.5	3.5	81.9	30.230	72.2	30.113	4	....	Cu. str.	NW. by W.	2	....	...do ...	Libbey.
		6	....	71.3	68.8	69.0	66.0	3.0	84.6	30.245	72.0	30.128	2	....	Cu. str.	NW.	3	....	...do ...	Do.
J.12, No. 72	39° 22′ 0″ N., 71° 22′ 0″ W.	7	....	71.5	71.4	71.8	67.8	4.0	80.3	30.248	72.8	30.130	½	....	Cu. str.	NW.	3	....	...do ...	Do.
		*8	....	72.3	74.0	74.2	69.3	4.9	76.4	30.268	74.2	30.146	½	....	Cu. str.	NW.	2	....	...do ...	Do.
		9	L. 9–12	71.9	73.5	73.3	68.1	5.2	76.1	30.266	73.0	30.147	½	....	Cu. str.	NW. by W.	2	....	...do ...	Magie.
		10	....	72.4	73.2	73.2	68.7	4.5	78.5	30.252	74.0	30.130	2	....	Cu. str.	NW.	2	....	...do ...	Do.
J.11, No. 73	39° 30′ 20″ N., 71° 20′ 0″ W.	11	....	72.5	73.2	73.2	68.9	4.3	78.5	30.266	74.0	30.144	0	Haze.		NW. by W.	2	....	...do ...	Do.
		12	....	72.8	74.2	74.0	69.0	5.0	76.4	30.232	74.0	30.110	0	Haze.		NW. by W.	3	....	...do ...	Do.
		13	....	72.4	74.0	74.1	69.4	4.7	78.7	30.246	76.3	30.119	0	Haze.		NW. by W.	3	....	...do ...	Libbey.
J.10, No. 74	39° 40′ 20″ N., 71° 21′ 30″ W.	14	H. 2–43	72.2	75.3	75.4	70.2	5.2	76.8	30.240	75.6	30.115	0	Haze.		WNW.	3	....	...do ...	Do.
		15	....	72.3	74.6	74.8	70.8	4.0	81.1	30.250	75.8	30.124	0	Haze.		W.	3	....	...do ...	Do.
J. 9, No. 75	39° 52′ 0″ N., 71° 19′ 0″ W.	16	....	72.1	73.6	73.8	70.0	3.8	81.0	30.200	76.0	30.073	0	Haze.		W.	3	....	...do ...	Do.
		17	....	71.6	73.2	73.0	69.7	3.3	83.0	30.176	74.5	30.053	0	Thick haze.		W.	3	†.44	...do ...	Magie.
		18	....	71.2	71.5	71.5	68.2	3.3	82.7	30.164	75.7	30.038	2	Thick haze.		W.	3	....	...do ...	Do.
J. 8, No. 76	40° 2′ 0″ N., 71° 21′ 0″ W.	19	....	70.8	71.2	71.2	68.5	2.7	87.3	30.164	75.3	30.039	4	Cir ...	Str	W.	4	....	...do ...	Do.
		20	....	70.8	71.3	71.3	68.5	2.8	87.4	30.162	74.5	30.040	0	....	Str	W.	4	....	...do ...	Do.
		21	....	71.0	71.3	71.5	68.5	3.0	85.0	30.210	74.5	30.087	0	....	Str	W.	4	....	...do ...	Rockwood.
J. 7, No. 77	40° 12′ 0″ N., 71° 20′ 0″ W.	22	L. 10–30	71.0	71.5	71.7	69.8	1.9	89.9	30.172	74.0	30.050	1	....	Str	W. by S.	4	....	...do ...	Do.
		23	....	71.0	71.4	71.8	69.8	2.0	89.9	30.164	74.5	30.041	2	....	Str	W. by S.	5	....	...do ...	Do.
J. 6, No. 78	40° 22′ 0″ N., 71° 20′ 0″ W.	24	....	71.0	71.8	72.0	70.0	2.0	90.0	30.160	74.0	30.038	4	....	Cu. str.	W. by S.	4	....	...do ...	Do.

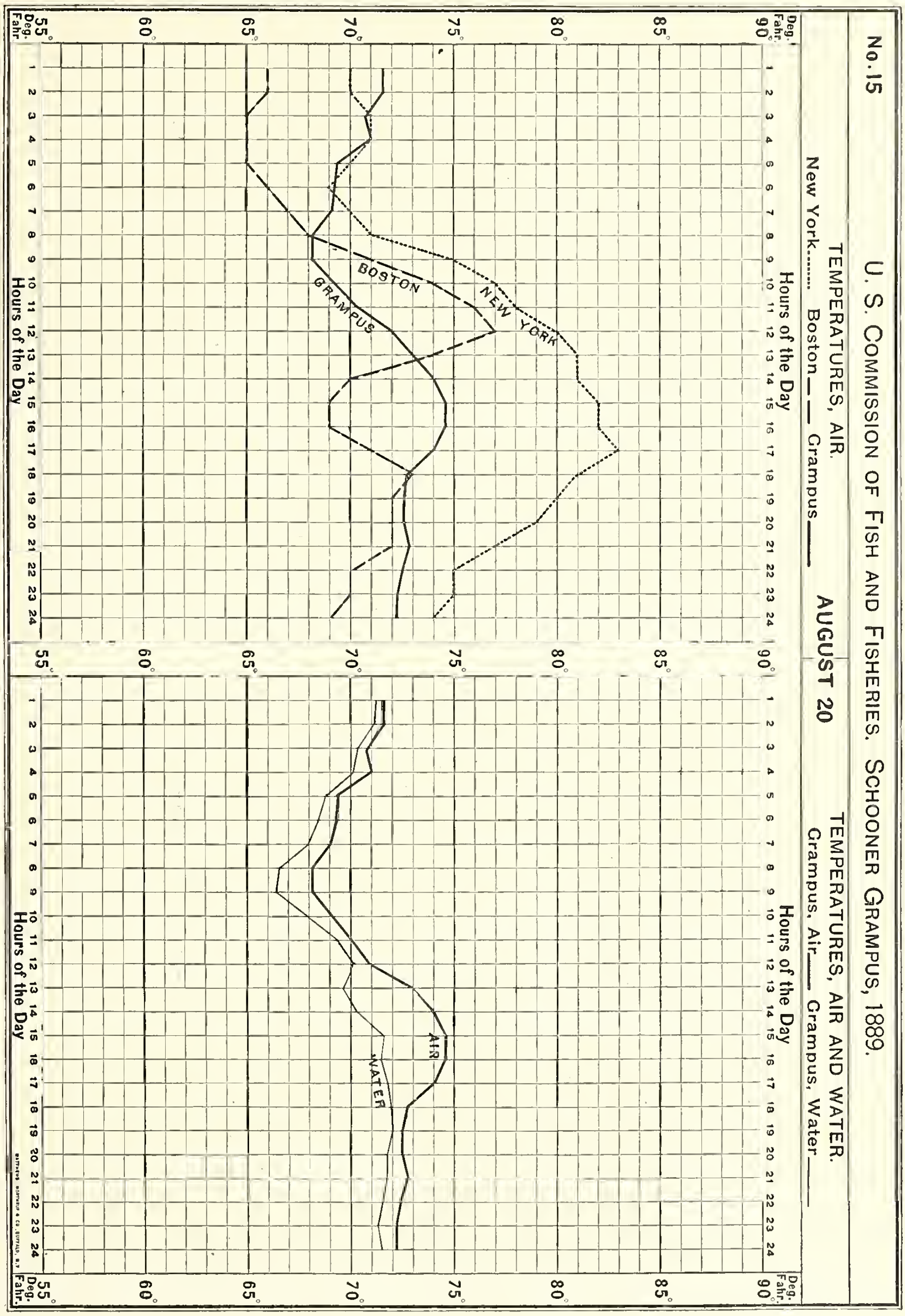
* Sun on thermometer box.

† Evaporation.

Table 15.

Date, August 20, 1889. Solar radiation thermometer, 126° F. Maximum temperature, 84° F. Six's, 82.5° F.
Terrestrial radiation thermometer, 61.3° F. Minimum temperature, 67.4° F. Six's, 67.5° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0—10.	Upper.	Lower.	Direction.	Force.			
J. 5, No. 79	40° 32′ 0″ N., 71° 20′ 0″ W.	1	....	71.2	71.6	72.0	70.7	1.3	92.3	30.140	74.5	30.017	8	....	Cum...	WSW.	5	In. .12	Mod. sw.	Libbey.
		2	....	71.1	71.6	71.8	71.0	0.8	97.5	30.128	74.3	30.006	9	....	Cum...	WSW.	5	...	...do	Do.
J. 4, No. 80	40° 42′ 0″ N., 71° 20′ 0″ W.	3	H. 3–48	70.5	70.8	71.0	70.8	0.2	100.0	30.090	74.1	29.968	8	....	Str	WSW.	5	....	...do	Do.
		4	....	70.3	71.0	71.2	70.3	0.9	94.9	30.080	74.2	29.958	9	....	Cu. str.	WSW.	5	....	...do	Do.
		5	....	68.8	69.4	69.4	68.8	0.6	97.3	30.062	75.0	29.937	10	....	Cu. str.	WSW.	5	....	...do	Magie.
J. 3, No. 81	40° 52′ 0″ N., 71° 20′ 0″ W.	6	....	68.5	69.3	69.5	68.9	0.6	97.3	30.052	75.0	29.927	9	....	Cu. str.	WSW.	5	....	...do ..	Do.
		7	....	68.0	69.1	69.3	68.9	0.4	97.4	30.068	74.5	29.944	5	Cir ...	Cu. str.	W. by S.	4	....	...do	Do.
		8	....	66.5	68.2	68.3	67.6	0.7	97.3	30.058	73.5	29.938	8	Cir ...	Cu. str.	W.	4	...	...do	Do.
		9	....	66.4	68.2	68.2	67.6	0.6	97.3	30.074	72.5	29.956	8	....	Cu. str.	W.	3	..	Calm ...	Rockwood.
K. 3, No. 82	40° 52′ 0″ N., 71° 30′ 0″ W.	10	L. 10–3	67.9	69.1	69.3	68.3	1.0	94.7	30.062	75.0	29.937	8	....	Cu. str.	W.	3	....	Mod. sw.	Do.
		11	....	69.2	70.1	70.0	69.0	1.0	94.8	30.040	73.5	29.920	6	....	Cir. str.	W.	3	..	...do	Do.
		12	....	70.1	71.9	72.0	70.0	2.0	90.0	30.044	74.0	29.922	6	....	Cir. str.	W. by S.	3	....	...do	Do.
K. 4, No. 83	40° 42′ 0″ N., 71° 30′ 0″ W.	13	....	69.7	73.0	73.0	70.4	2.6	87.7	30.052	75.0	29.927	0	Haze.		W.	3	....	.. do	Magie.
		14	....	70.2	73.9	73.9	71.9	2.0	90.2	30.040	75.0	29.915	0	Haze.		W.	3	....	...do	Do.
K. 5, No. 84	40° 32′ 0″ N., 71° 30′ 0″ W.	15	H. 3–33	71.4	74.5	74.5	71.4	3.1	85.6	30.026	75.0	29.901	0	Haze.		W.	3	....	.. do	Do.
		16	....	71.3	74.5	74.5	71.7	2.8	85.4	30.036	75.0	29.911	0	Haze.		W.	3	....	...do ...	Do.
K. 6, No. 85	40° 22′ 0″ N., 71° 30′ 0″ W.	17	....	71.8	74.0	73.8	71.9	1.9	90.2	30.064	75.5	29.938	0	Haze.		W.	3	....	...do	Rockwood.
		18	....	71.9	72.8	72.6	71.1	1.5	92.5	30.066	75.5	29.940	5	Cir ...	Str	W.	4	...	...do ...	Do.
K. 7, No. 86	40° 12′ 0″ N., 71° 30′ 0″ W.	19	....	72.0	72.6	73.0	71.7	1.3	92.5	30.060	75.0	29.937	7	Cir ..	Str	WNW.	3	....	...do	Do.
		20	....	71.8	72.6	72.8	71.8	1.0	95.0	30.066	75.5	29.940	4	....	Str	WNW.	3	...	...do	Do.
K. 8, No. 87	40° 2′ 0″ N., 71° 30′ 0″ W.	21	....	71.8	72.8	73.0	72.0	1.0	95.0	30.064	75.8	29.938	2	....	Str	WNW.	3	....	...do	Libbey.
		22	....	71.5	72.6	72.8	72.0	0.8	97.5	30.070	75.8	29.944	2	....	Str	WNW.	3	....	...do ...	Do.
K. 9, No. 88	39° 52′ 0″ N., 71° 30′ 0″ W.	23	L. 11–20	71.3	72.3	72.4	71.8	0.6	97.5	30.068	75.5	29.942	4	....	Str	W. by W.	1	....	...do ...	Do.
		24	....	71.6	72.3	72.3	72.0	0.3	97.5	30.070	75.5	29.944	3	....	Str	W. by N.	½	....	...do ...	Do.


No. 15
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston— — Grampus——
AUGUST 20
TEMPERATURES, AIR AND WATER.
Grampus, Air—— Grampus, Water——
Hours of the Day
Deg. Fahr.
BOSTON
NEW YORK
GRAMPUS
AIR
WATER

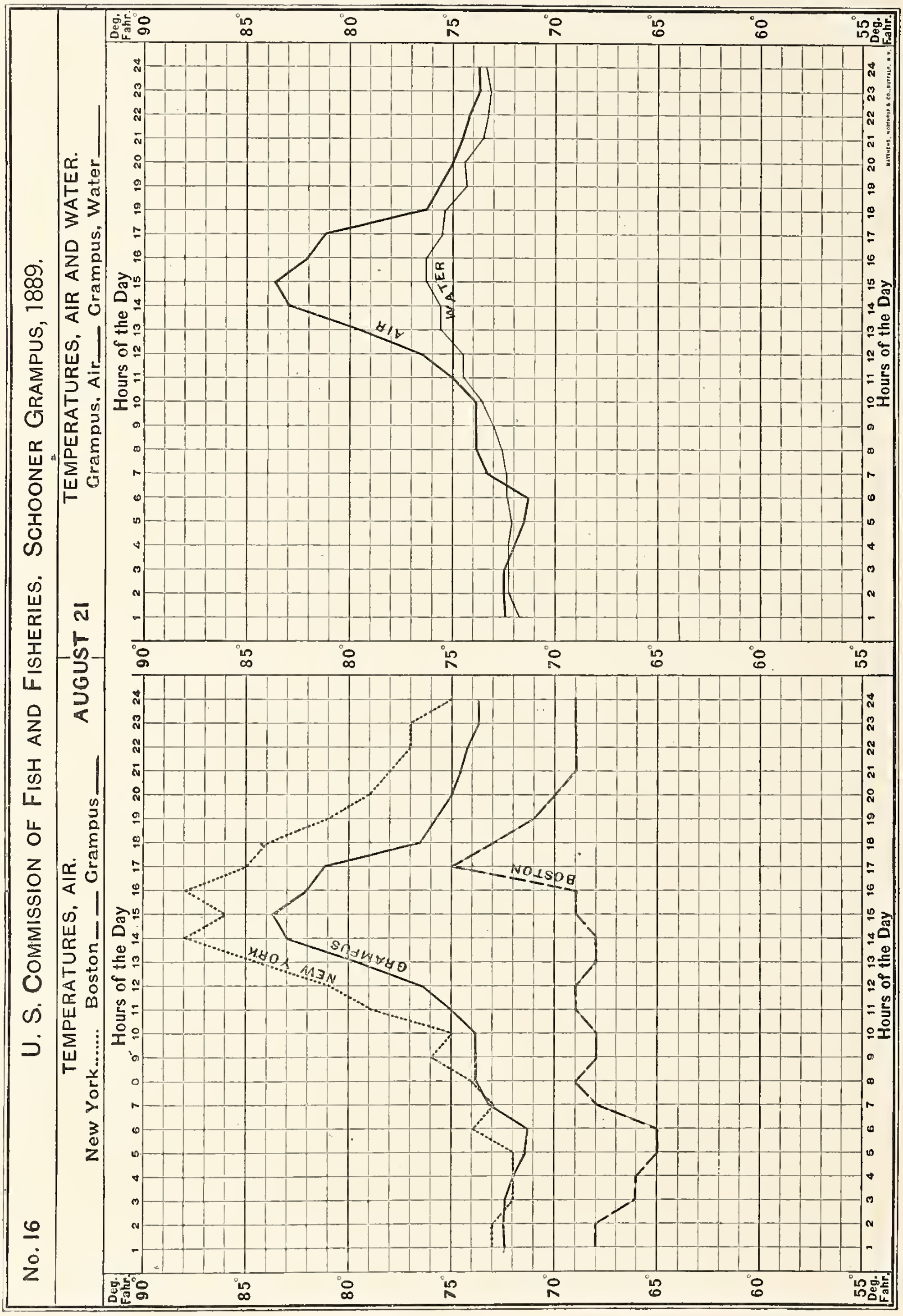

No. 16
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston___ Grampus___
AUGUST 21
TEMPERATURES, AIR AND WATER.
Grampus, Air___ Grampus, Water___
Hours of the Day
Deg. Fahr.
NEW YORK
GRAMPUS
BOSTON
AIR
WATER

TABLE 16.

Date, August 21, 1889. Solar radiation thermometer, 122° F. Maximum temperature, 84° F. Six's, 83° F.
Terrestrial radiation thermometer, 70.1° F. Minimum temperature, 62.8° F. Six's, 62° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°	0—10.	Upper.	Lower.	Direction.	Force.	In.		
		1	....	71.7	72.5	72.5	72.2	0.3	97.5	30.074	76.0	29.947	3	....	Str ...	W.	2	....	Calm ...	Magie.
K. 10, No. 89	39° 42′ 0″ N., 71° 30′ 0″ W.	2	....	72.2	72.6	72.7	72.2	0.5	97.5	30.062	76.0	29.935	0	Haze.		W.	2	....	...do	Do.
		3	....	72.3	72.4	72.6	72.3	0.3	97.5	30.064	76.0	29.937	0	Haze.		W.	2	....	...do	Do.
		4	H. 4–38	72.2	72.1	72.1	72.0	0.1	100.0	30.068	76.0	29.941	0	Haze.		W.	2	....	...do ...	Do.
		5	....	72.2	71.6	71.7	71.0	0.7	97.5	30.060	75.0	29.935	7	Cir ..	Str ...	W.	2	....	...do	Rockwood.
		6	....	72.4	71.4	71.5	71.2	0.3	97.5	30.068	75.0	29.943	4	Cir ..	Cu.str.	W.	2	....	Mod. sw.	Do.
K. 11, No. 90	39° 32′ 0″ N., 71° 30′ 0″ W.	*7	....	72.4	73.3	73.5	73.0	0.3	97.5	30.078	75.5	29.952	3	Cir ..	Str ...	W.	2	....	...do	Do.
		8	....	72.7	73.9	74.0	72.0	2.0	90.0	30.090	75.5	29.963	3	Cir ..	Str ...	NNW.	1	....	...do ...	Do.
		9	....	73.0	73.9	74.0	72.0	2.0	90.0	30.100	75.5	29.973	3	Cir ..	Str ..	....	0	....	.. do ...	Libbey.
		10	L. 10–50	73.6	73.9	74.0	72.0	2.0	90.0	30.114	75.8	29.988	3	Cir ..	Str ...	WSW.	1	....	...do	Do.
		11	....	74.6	75.0	75.2	72.5	2.7	88.1	30.120	76.4	29.993	8	Cir ..	Str ...	WSW.	1	....	...do	Do.
		12	....	74.6	76.5	76.9	73.2	3.7	83.8	30.122	76.7	29.994	5	Cir ..	Str ...	WSW.	1	....	...do	Do.
K. 12, No. 91	39° 22′ 0″ N., 71° 30′ 0″ W.	13	....	75.5	79.6	79.6	75.0	4.6	80.2	30.090	78.5	29.956	5	Cir ..	Str ...	WSW.	1	....	...do ...	Rockwood.
		*14	....	75.5	83.0	82.8	76.8	6.0	74.7	30.090	78.5	29.956	4	Cir ..	Str ...	SW. by W.	1	....	...do	Do.
		*15	....	76.2	83.8	83.2	76.7	6.5	72.9	30.092	79.0	29.957	0	Haze.		SW. by W.	1	....	...do	Do.
		*16	H. 4–18	76.2	82.0	82.0	76.6	5.4	76.6	30.086	79.5	29.950	0	Haze.		SW. by W.	1	....	.. do	Do.
		17	....	75.4	81.2	79.7	76.2	3.5	85.5	30.090	80.0	29.952	3	......	Str ...	SW. by W.	1	....	...do	Libbey.
		18	....	75.3	76.3	76.6	75.0	1.6	92.9	30.084	79.6	29.947	4	Cir ..	Str ...	SW. by W.	1	....	...do	Do.
H. 12, No. 92	39° 22′ 0″ N., 71° 10′ 0″ W.	19	....	74.2	75.7	75.8	75.0	0.8	95.2	30.068	79.0	29.923	4	Cir ..	Str ...	SW. by W.	1	....	...do	Do.
		20	....	74.4	75.0	75.2	74.8	0.4	97.6	30.080	79.8	29.943	2	....	Str ...	SW. by W.	2	....	...do	Do.
		21	....	73.5	74.5	74.6	74.3	0.3	97.6	30.070	79.0	29.935	0	....	....	SW. by W.	2	....	...do	Magie.
H. 11, No. 93	39° 32′ 0″ N., 71° 10′ 0″ W.	22	....	73.4	74.1	74.3	74.0	0.3	97.6	30.078	78.0	29.945	0	....	....	SW.	2	....	...do ...	Do.
		23	....	73.2	73.7	73.9	73.5	0.4	97.5	30.072	77.5	29.941	0	....	....	SW.	2	....	...do	Do.
		24	L. 12–5	73.5	73.7	73.9	73.5	0.4	97.5	30.062	78.0	29.931	0	....	... ...	SW.	2	....	...do ...	Do.

*Sun on thermometer box.

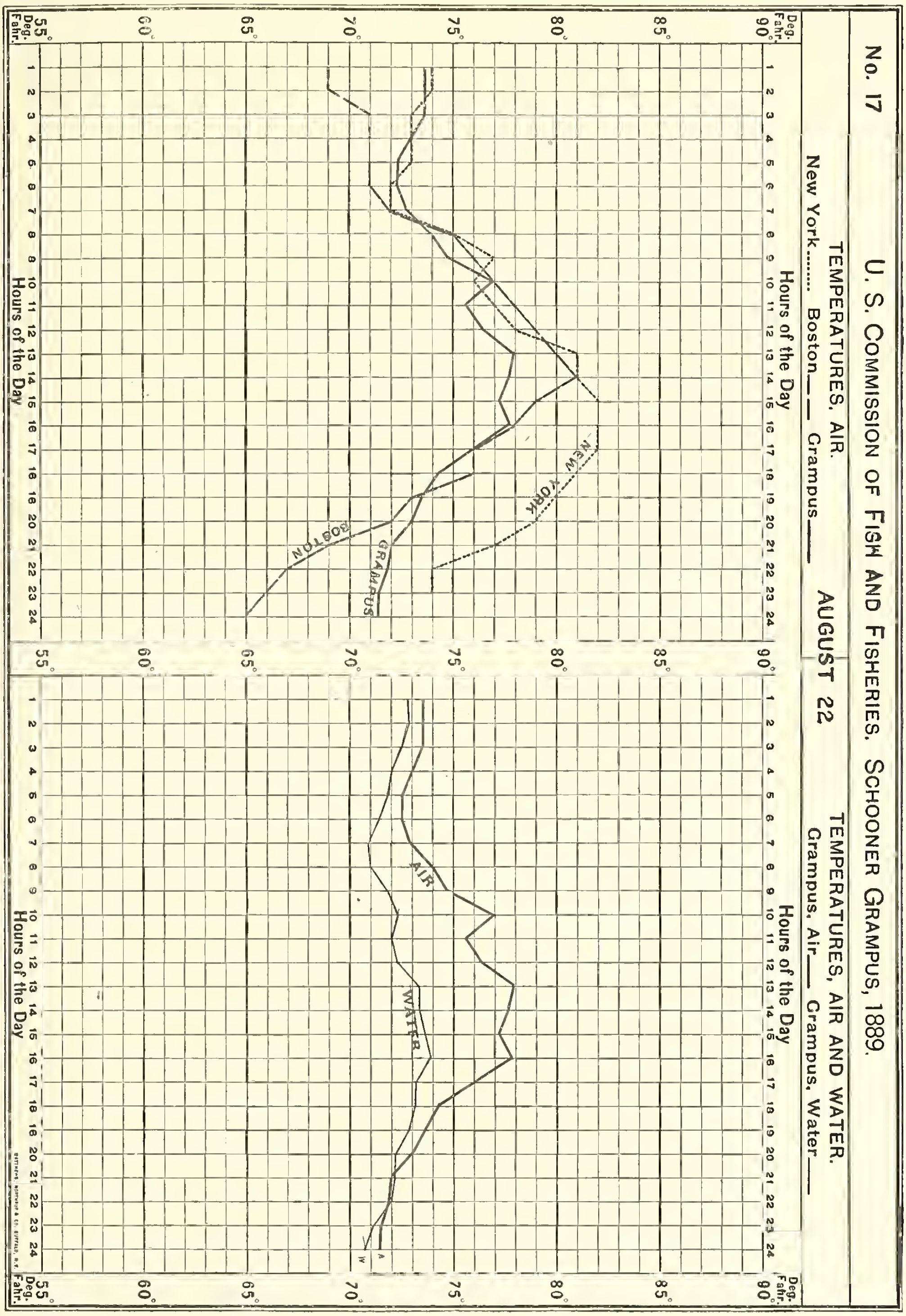
TABLE 17.

Date, August 22, 1889. Solar radiation thermometer, 132.3° F. Maximum temperature, 81.3° F. Six's, 79° F.
Terrestrial radiation thermometer, 71° F. Minimum temperature, 72° F. Six's, 72° F.

Station.	Position.	Hour.	Tide.	Temperature. Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Barometer. Reading.	t.	=32°.	Clouds. 0–10.	Upper.	Lower.	Wind. Direction.	Force.	Rain.	State of sea.	Observer.
H. 10, No. 94	39° 42′ 0″ N., 71° 10′ 0″ W.	1	....	72.9	73.6	73.6	73.1	0.5	97.5	30.016	77.0	29.880	1	....	Str	SW.	3	In. ...	Calm ..	Rockwood.
		2	....	72.9	73.6	73.8	73.0	0.8	95.1	30.024	77.0	29.894	1	....	Str	SW.	3	....	...do ..	Do.
		3	....	72.6	73.6	73.6	73.0	0.6	97.5	30.020	77.0	29.890	1	....	Cu. str.	SW.	4	....	...do ...	Do.
H. 9, No. 95	39° 51′ 0″ N., 71° 10′ 0″ W.	4	....	72.0	73.0	73.0	72.5	0.5	97.5	30.008	77.0	29.878	1	....	Str	WSW.	4	....	...do ...	Do.
		5	H. 5–19	71.9	72.5	72.8	72.5	0.3	97.5	30.013	76.8	29.885	1	....	Haze ..	SW. by W.	3	....	...do ...	Libbey.
		6	....	71.5	72.4	72.4	72.2	0.2	100.0	30.013	79.2	29.877	3	Cir ..	Str	WSW.	3	....	...do ...	Do.
H. 8, No. 96	40° 2′ 0″ N., 71° 10′ 0″ W.	7	....	70.8	72.8	73.0	72.5	0.5	97.5	30.018	76.5	29.890	3	Cir ..	Str	SW. by W.	3	....	-- do ...	Do.
		8	....	71.0	74.0	74.0	73.0	1.0	95.1	30.020	77.8	29.889	2	....	Str	WSW.	4	....	...do ...	Do.
G. 7, No. 97	40° 12′ 0″ N., 71° 3′ 0″ W.	9	....	71.8	74.8	75.0	73.4	1.6	92.7	30.024	76.7	29.896	0		Haze.	WSW.	4	...	.. do ...	Magie.
		*10	....	72.2	77.0	77.1	75.0	2.1	90.7	30.008	77.0	29.878	0		Haze.	W.	4	....	...do ...	Do.
H. 6, No. 98	40° 22′ 0″ N., 71° 6′ 0″ W.	11	L. 11–32	72.0	75.5	75.5	73.4	2.1	90.4	30.020	76.0	29.893	0		Haze.	W.	4	....	...do ...	Do.
		12	....	72.3	76.2	76.2	73.5	2.7	88.2	30.020	78.0	29.887	0		Haze.	WNW.	3	....	...do ...	Do.
		13	....	73.2	78.0	78.4	72.6	5.8	73.4	30.010	78.5	29.876	0		Haze.	WNW.	1	...	...do ...	Libbey.
H. 5, No. 99	40° 32′ 0″ N., 71° 10′ 0″ W.	14	....	73.2	77.8	78.0	72.0	6.0	73.4	30.016	78.8	29.882	0		Haze.	WNW.	1		...do ...	Do.
		15	....	73.4	77.2	77.6	72.0	5.6	75.4	29.990	78.5	29.856	0		Haze.	WNW.	1	†.50	-- do ...	Do.
		16	H. 4–58	73.9	77.8	78.0	71.8	6.2	73.1	30.012	78.5	29.878	0		Haze.	WNW.	1	....	...do ...	Do.
		17	....	73.2	76.0	76.1	70.2	5.9	72.9	30.014	78.7	29.880	0		Haze.	WNW.	1	....	...do ...	Magie.
		18	....	73.2	74.1	74.2	70.9	3.3	83.1	30.016	79.0	29.881	0		Haze.	WNW.	1	....	...do ...	Do.
H. 4, No. 100	40° 42′ 0″ N., 71° 14′ 0″ W.	19	....	72.8	73.5	73.5	71.3	2.2	90.2	30.028	80.0	29.890	0		Haze.	WSW.	1	....	...do ...	Do.
		20	....	72.3	73.0	73.0	71.5	1.5	92.5	30.052	78.0	29.919	0		Haze.	W. by S.	1	....	-- do ...	Do.
		21	....	72.2	72.0	72.3	71.0	1.3	92.5	30.066	77.5	29.935	0		Haze.	WSW.	1	....	...do ...	Rockwood.
		22	....	72.0	71.9	72.0	71.0	1.0	95.0	30.070	77.0	29.940	0		Haze.	WSW.	1	....	-- do ...	Do.
		23	....	71.2	71.4	71.8	71.0	0.8	95.0	30.088	76.5	29.960	0		Haze.	WSW.	1	....	...do ...	Libbey.
H. 3, No. 101	40° 52′ 0″ N., 71° 15′ 0″ W.	24	....	70.8	71.3	71.3	71.0	0.3	97.5	30.094	76.0	29.967	0		Haze.	SW.	1	....	...do ...	Rockwood.

* Sun on thermometer box.

† Evaporation.


No. 17
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES. AIR.
New York...... Boston.___ Grampus.___
AUGUST 22
TEMPERATURES, AIR AND WATER.
Grampus. Air___ Grampus. Water___
Hours of the Day
Deg. Fahr.
90°
85°
80°
75°
70°
65°
60°
55°
NEW YORK
BOSTON
GRAMPUS
AIR
WATER

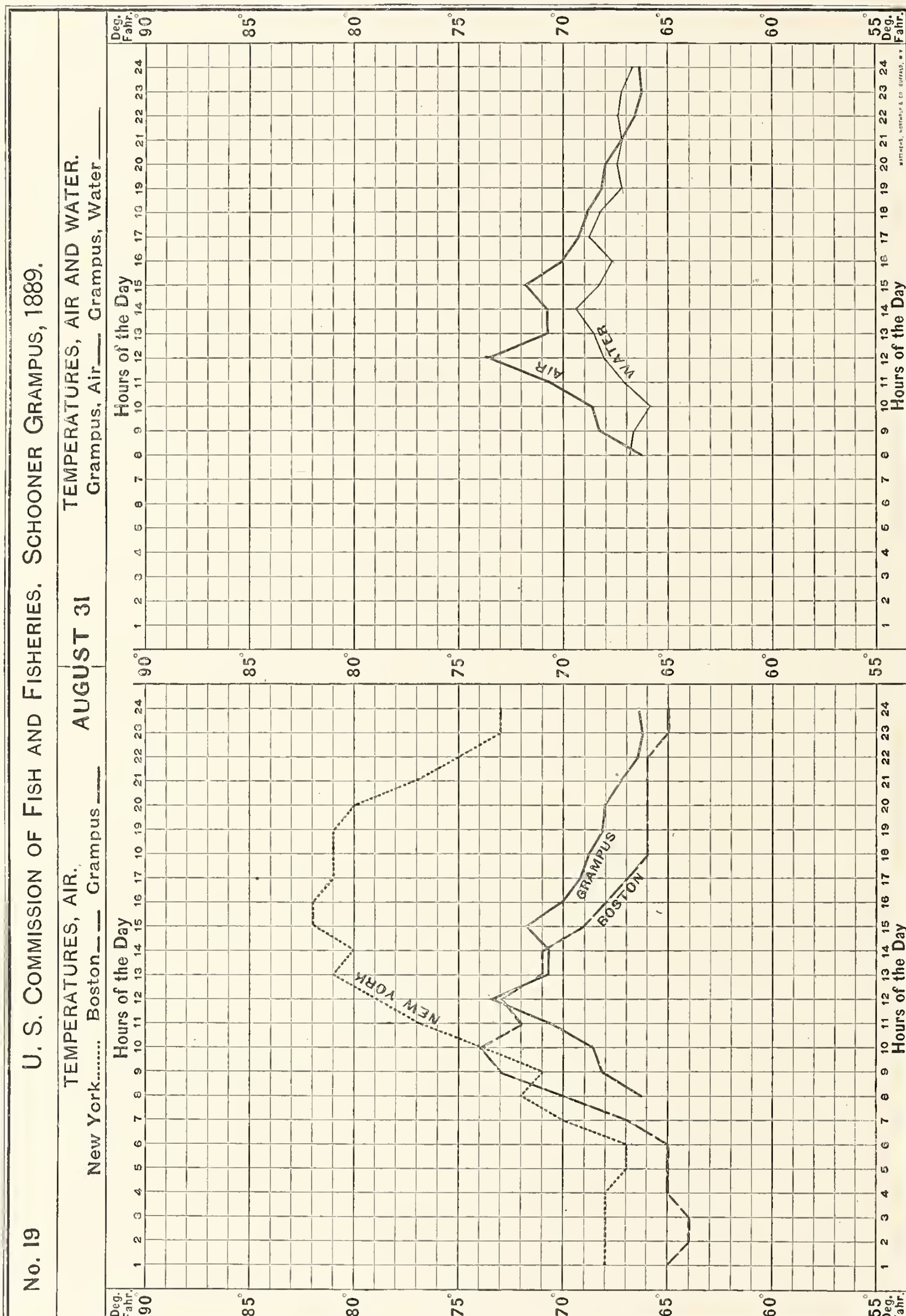

No. 19
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York....... Boston.___ Grampus___
AUGUST 31
TEMPERATURES, AIR AND WATER.
Grampus, Air___ Grampus, Water___
Hours of the Day
Deg. Fahr.
NEW YORK
GRAMPUS
BOSTON
AIR
WATER

TABLE 18.

Date, August 27, 1889. Solar radiation thermometer, 112° F. Maximum temperature, 70.4° F. Six's, 71° F.
Terrestrial radiation thermometer, 61° F. Maximum temperature, 61.4° F. Six's, 62° F.

Station.	Position.	Hour.	Tide.	Temperature. Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Barometer. Reading.	t.	=32°.	Clouds. 0—10.	Upper.	Lower.	Wind. Direction.	Force.	Rain.	State of sea.	Observer.
																		In.		
		2	L. 2-36																	
		8	H. 8-0																	
		14	L. 2-44																	
		20	H. 8-17	63.0	63.1	63.0	60.2	2.8	83.1	30.336	66.5	30.233	1		Str	ENE.	3		Mod. sw	Magie.
J. 1, No. 102	41° 12′ 0″ N., 71° 20′ 0″ W.	21		64.5	63.0	63.0	61.0	2.0	88.6	30.342	66.5	30.240	1		Str	ENE.	3		do	Do.
		22		63.0	62.8	62.5	61.8	0.7	97.0	30.340	66.4	30.237	0			ENE.	3		do	Libbey.
J. 2, No. 103	41° 2′ 0″ N., 71° 20′ 0″ W.	23		64.3	63.0	63.2	62.0	1.2	94.2	30.328	66.0	30.225	0			ENE.	5		do	Do.
		24		64.7	63.3	63.2	62.0	1.2	94.2	30.330	66.4	30.230	0			ENE.	6		Heavy sw.	Do.

TABLE 19.

Date, August 31, 1889. Solar radiation thermometer, 135° F. Maximum temperature, 77.5° F. Six's, 78° F.
Terrestrial radiation thermometer, 62.4° F. Minimum temperature, 57.8° F. Six's, 58° F.

Station.	Position.	Hour.	Tide.	Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0—10.	Upper.	Lower.	Direction.	Force.	Rain.	State of sea.	Observer.
		5	L. 5-34																	
		8		66.8	66.3	67.1	66.0	1.1	94.6	30.230	68.8	30.124	½	Cir	Haze	N. by W.	2		Calm	McNeill.
		9		66.7	68.2	69.0	66.9	2.1	89.5	30.221	69.4	30.111	0		Haze	N. by W.	2		do	Do.
		10		65.9	68.6	69.0	66.9	2.1	89.5	30.228	69.4	30.118	0		Haze	NE. by N.	2		do	Do.
		11	H. 11-15	67.1	70.7	71.0	68.9	2.1	89.8	30.227	70.0	30.116	0	Cir	Haze	NE. by N.	2		do	Do.
K. 1, No. 104	41° 12′ 0″ N., 71° 30′ 0″ W.	12		68.1	73.7	73.6	70.1	3.5	83.2	30.241	71.6	30.126	0	Cir	Haze	NE.	1		do	Do.
		13		68.5	70.8	70.8	69.0	1.8	89.9	30.226	72.3	30.109	2	Cir	Haze	NE. by N.	1		do	Libbey.
		14		69.3	70.8	70.9	69.3	1.6	92.3	30.232	72.8	30.114	1	Cir. str.	Haze	NE. by N.	1		do	Do.
		15		68.2	71.8	72.0	70.2	1.8	90.0	30.250	72.2	30.133	1	Str	Haze	E. by S.	1		do	Do.
		16		67.8	70.0	70.2	68.8	1.4	92.2	30.260	72.0	30.143	0		Haze	S.	1		do	Do.
		17		68.7	69.3	69.4	68.0	1.4	92.2	30.256	73.0	30.137	1	Cir	Haze	ESE.	1		do	Magie.
K. 2, No. 105	41° 2′ 0″ N., 71° 31′ 15″ W.	18	L. 6-43	68.2	68.9	68.9	68.0	1.9	89.8	30.262	73.0	30.143	0		Haze	ENE.	2		do	Do.
		19		67.1	68.1	68.0	67.5	0.6	97.3	30.250	72.0	30.133	0		Haze	E.	3		do	Do.
		20		67.5	68.0	68.2	67.7	0.5	97.3	30.264	72.0	30.147	0		Haze	E.	3		do	Do.
K. 3, No. 106	40° 52′ 0″ N., 71° 30′ 0″ W.	21		67.2	67.3	68.0	67.4	0.6	97.3	30.258	70.7	30.145	0		Haze	E.	3		do	McNeill.
		22		67.3	66.6	67.1	66.7	0.4	97.3	30.273	71.0	30.159	0		Haze	NE.	3		do	Do.
K. 4, No. 107	40° 42′ 0″ N., 71° 30′ 0″ W.	23		67.2	66.3	66.9	66.5	0.4	97.3	30.301	71.0	30.190	0		Haze	NE. by E.	4		do	Do.
K. 5, No. 108	40° 32′ 0″ N., 71° 30′ 0″ W.	24	H. 12-0	66.5	66.4	66.8	66.8	0.0	100.0	30.296	70.2	30.185	10		Fog	E.	5		do	Do.

TABLE 20.

Date, September 1, 1889. Solar radiation thermometer, 129.4° F. Maximum temperature, 72.8° F. Six's, 72° F.
Terrestrial radiation thermometer, 63.2° F. Minimum temperature, 57.8° F. Six's, 59° F.

Station.	Position.	Hour.	Tide.	Temperature. Water.	Temperature. Air.	Temperature. Dry bulb.	Temperature. Wet bulb.	Temperature. Difference.	Temperature. Relative humidity.	Barometer. Reading.	Barometer. t.	Barometer. =32°.	Clouds. 0—10.	Clouds. Upper.	Clouds. Lower.	Wind. Direction.	Wind. Force.	Rain.	State of sea.	Observer.
																		In.		
		6	L. 6-39	......	......	......	......	......	......	......	......	......	...	....	....	....	...	....	....	
		9	....	66.5	67.2	67.8	66.1	1.7	92.0	30.391	70.0	30.280	0	....	Haze .	NE.	4	*.20	Mod. sw.	McNeill.
		10	....	66.2	67.9	68.4	65.9	2.5	86.9	30.383	71.0	30.269	0	....	Haze .	NE.	3	....	...do	Do.
		11	....	65.4	67.9	68.3	65.9	2.4	86.8	30.379	69.5	30.269	0	....	Haze .	NE.	3	....	...do	Do.
J. 3, No. 109	40° 52′ 0″ N., 71° 20′ 0″ W.	12	H. 12-16	65.8	69.2	69.4	66.0	3.4	82.2	30.388	69.7	30.278	0	....	Haze .	NNE.	3	....	...do	Do.
		13	....	67.3	67.8	67.9	65.0	2.9	84.3	30.395	69.2	30.286	1	Cir ...	Haze .	NNE.	3	....	...do	Magie.
J. 4, No. 110	40° 42′ 0″ N., 71° 20′ 0″ W.	14	....	67.4	68.9	68.9	66.0	2.9	84.6	30.380	70.5	30.267	0	....	Haze .	NNE.	3	....	...do	Do.
J. 5, No. 111	40° 32′ 0″ N., 71° 20′ 0″ W.	15	....	67.0	68.1	68.1	66.2	1.9	89.5	30.382	73.0	30.263	0	....	Haze .	NE.	4	....	...do	Do.
		16	....	66.3	68.2	68.2	66.3	1.9	89.5	30.386	73.0	30.267	0	....	Haze .	NE.	4	....	...do	Do.
J. 6, No. 112	40° 22′ 0″ N., 71° 20′ 0″ W.	17	....	66.0	67.4	67.8	66.2	1.6	92.0	30.370	70.2	30.259	0	....	Haze .	NE. by E.	4	....	Choppy.	McNeill.
		18	....	67.5	66.4	66.9	65.0	1.9	89.3	30.362	72.1	30.245	0	....	Haze .	NE. by E.	5	....	...do	Do.
J. 7, No. 113	40° 12′ 0″ N., 71° 20′ 0″ W.	19	L. 7-52	67.5	66.4	66.9	65.0	1.9	89.3	30.368	69.1	30.259	0	....	Haze .	NE. by E.	5	....	...do	Do.
		20	....	66.2	66.3	66.7	64.8	1.9	89.1	30.378	69.8	30.268	0	....	Haze	NE. by E.	5	....	...do	Do.

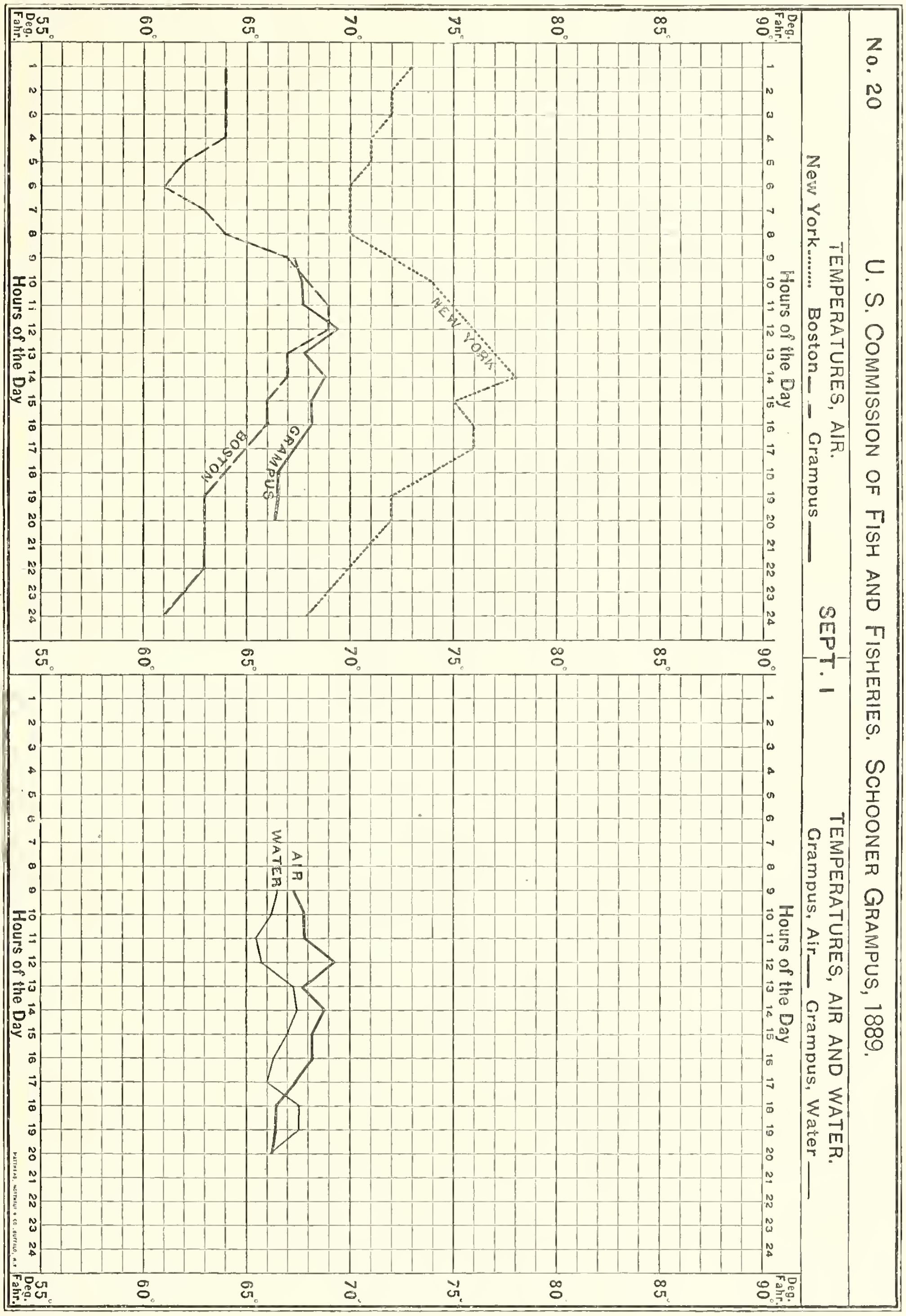
* Evaporation.

TABLE 21.

Date, September 2, 1889. Solar radiation thermometer, 128.5° F. Maximum temperature, 74° F. Six's, 73° F.
Terrestrial radiation thermometer, 59.3° F. Minimum temperature, 60° F. Six's, 60.2° F.

Station.	Position.	Hour.	Tide.	Temperature. Water.	Temperature. Air.	Temperature. Dry bulb.	Temperature. Wet bulb.	Temperature. Difference.	Temperature. Relative humidity.	Barometer. Reading.	Barometer. t.	Barometer. =32°.	Clouds. 0—10.	Clouds. Upper.	Clouds. Lower.	Wind. Direction.	Wind. Force.	Rain.	State of sea.	Observer.
		1	H. 1-12	......	......	......	......	......	......	......	......	......	...	....	....	....	...	....	....	
		7	L. 7-43	......	......	......	......	......	......	......	......	......	...	....	....	....	...	....	....	
		13	H. 1-20	......	......	......	......	......	......	......	......	......	...	....	....	....	...	....	....	
		19	....	66.3	65.8	65.8	63.7	2.1	89.0	30.304	68.8	30.196	0	....	....	SW.	2	*.26	Calm....	Libbey.
		20	L. 8-59	67.2	65.4	65.5	63.8	1.7	91.6	30.312	69.0	30.203	0	....	....	SW.	2	....	..do	Do.
		21	....	66.6	65.2	65.2	64.0	1.2	94.4	30.316	69.0	30.207	0	....	....	WSW.	2	....	...do	Do.
		22	....	65.1	65.1	65.0	64.0	1.0	94.4	30.316	67.9	30.211	0	....	....	WSW.	2	....	...do	Do.
H. 1, No. 114	41° 12′ 0″ N., 71° 10′ 0″ W.	23	....	65.2	65.1	65.0	64.0	1.0	94.4	30.306	67.5	30.202	0	....	....	WSW.	2	....	.. do	Do.
		24	....	64.4	64.6	64.7	63.5	1.2	94.3	30.290	68.0	30.184	0	....	....	WSW.	2	....	...do	Do.

* Evaporation.


No. 20
U. S. Commission of Fish and Fisheries. Schooner Grampus, 1889.
TEMPERATURES, AIR.
New York...... Boston— — Grampus——
SEPT. 1
TEMPERATURES, AIR AND WATER.
Grampus, Air— Grampus, Water —
Hours of the Day
Deg. Fahr.
NEW YORK
BOSTON
GRAMPUS
AIR
WATER

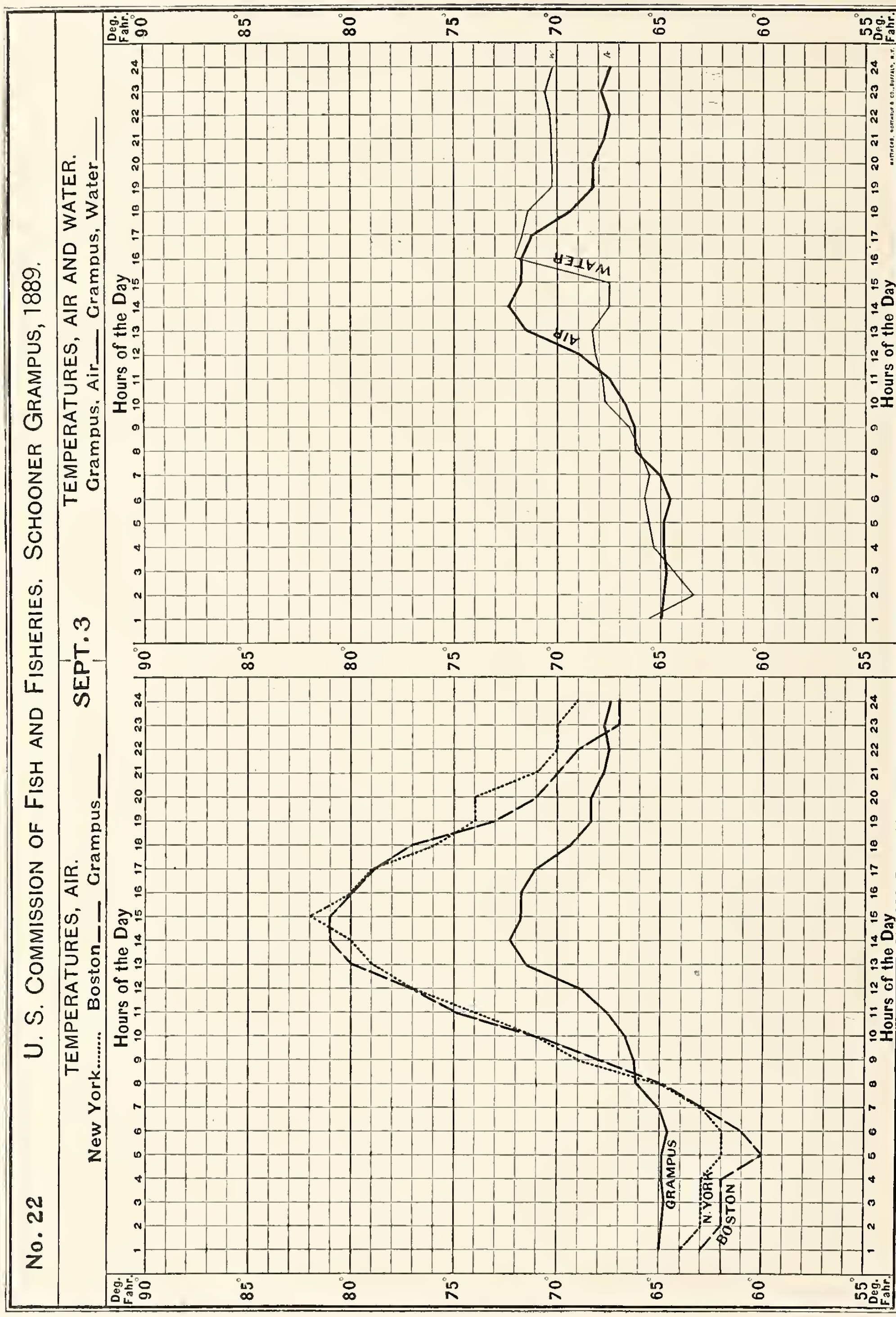

No. 22
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York....... Boston___ Grampus____
SEPT. 3
TEMPERATURES, AIR AND WATER.
Grampus, Air____ Grampus, Water____
Hours of the Day
Deg. Fahr.
GRAMPUS
N. YORK
BOSTON
AIR
WATER

Table 22.

Date, September 3, 1889. Solar radiation thermometer, 138.5° F. Maximum temperature, 75.9° F. Six's, 75° F.
Terrestrial radiation thermometer, 62.4° F. Minimum temperature, 63.5° F. Six's, 64° F.

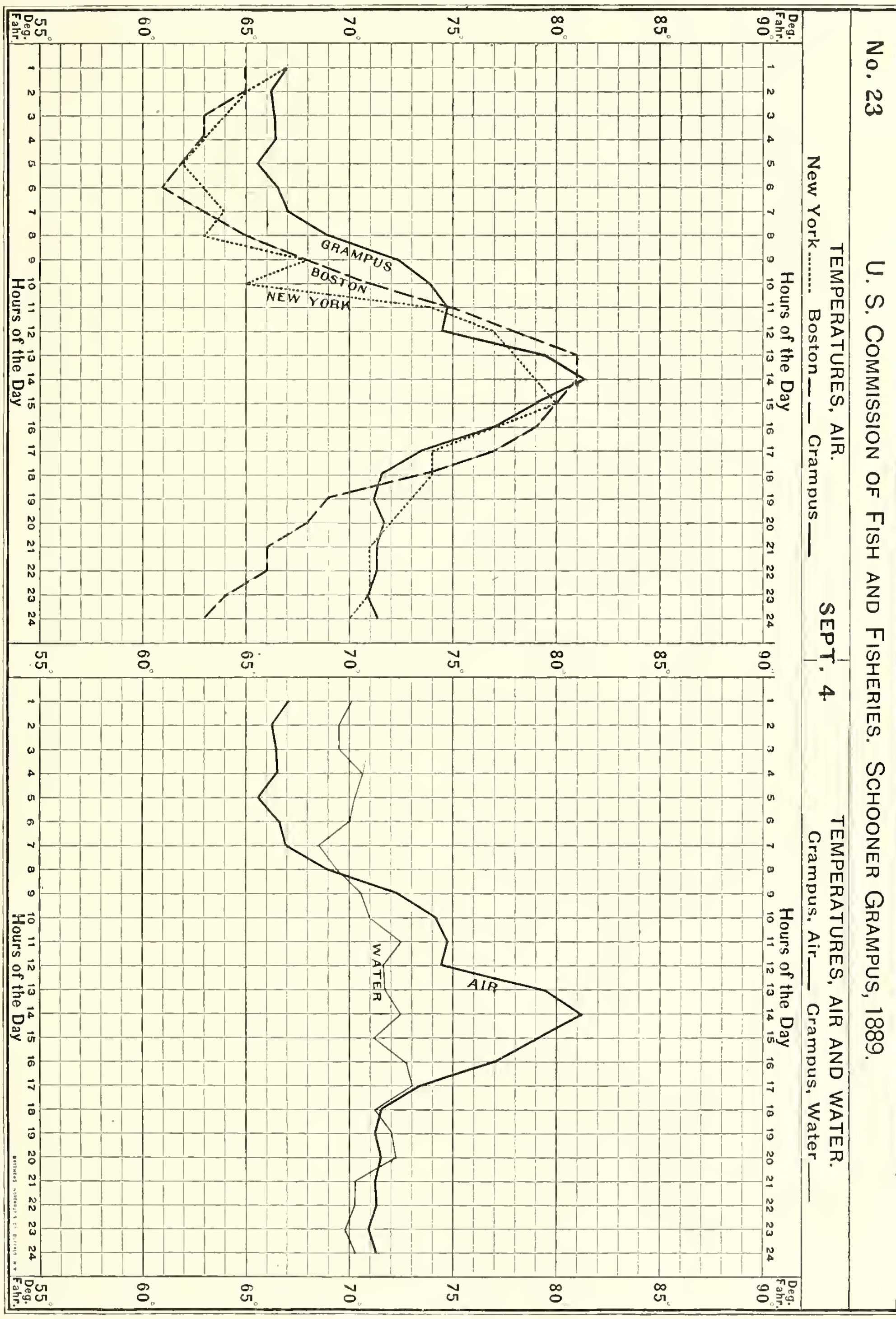
Station.	Position.	Hour.	Tide.	Temperature. Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Barometer. Reading.	t.	=32°	Clouds. 0–10.	Upper.	Lower.	Wind. Direction.	Force.	Rain.	State of sea.	Observer.
																		In.		
H. 2, No. 115	41° 2′ 0″ N., 71° 10′ 0″ W.	1	....	65.5	65.0	65.0	63.0	2.0	89.0	30.284	68.6	30.177	0	....	Haze..	W.	2	....	Calm...	Magie.
		2	H. 2-21	63.2	64.9	65.0	64.0	1.0	94.4	30.282	68.0	30.176	0	....	Haze..	WSW.	2	....	...do ...	Do.
		3	....	64.4	64.8	64.8	63.6	1.2	94.3	30.290	68.0	30.184	0	....	Haze..	WSW.	2	....	...do ...	Do.
H. 3, No. 116	40° 52′ 0″ N., 71° 10′ 0″ W.	4	....	65.1	64.9	64.9	64.1	0.8	97.2	30.284	67.5	30.179	0	....	Haze..	WSW.	2	....	...do ...	Do.
		5	....	65.4	64.9	65.2	64.0	1.2	94.4	30.298	67.8	30.193	0	....	Haze..	WSW.	2	....	...do ...	McNeill.
		6	....	65.7	64.7	64.8	64.2	0.6	97.2	30.317	67.4	30.213	0	....	Haze..	WSW.	2	....	...do ...	Do.
H. 4, No. 117	40° 42′ 0″ N., 71° 10′ 0″ W.	7	....	65.6	65.0	65.2	64.6	0.6	97.2	30.300	68.0	30.194	0	....	Haze..	WSW.	2	....	...do ...	Do.
		8	L. 8-48	66.1	66.2	66.7	65.8	0.9	94.5	30.285	68.1	30.179	0	....	Haze..	WSW.	2	....	...do ...	Do.
		9	....	66.4	66.3	66.7	65.3	1.4	91.9	30.304	68.0	30.198	0	....	Haze..	SW. by W.	2	....	...do ...	Do.
		10	....	67.7	66.8	67.0	65.5	1.5	91.9	30.312	68.8	30.204	0	....	Haze..	SW. by W.	2	....	...do ...	Libbey.
H. 5, No. 118	40° 31′ 0″ N., 71° 10′ 0″ W.	11	....	67.8	67.5	67.7	66.0	1.7	92.0	30.314	68.9	30.206	0	....	Haze..	SW.	2	....	...do ...	Do.
		12	....	68.2	68.8	69.2	66.5	2.7	87.0	30.300	69.0	30.189	0	....	Haze..	SW. by W.	2	....	...do ...	Do.
		13	....	68.3	71.4	71.8	67.9	3.9	80.2	30.285	70.0	30.174	0	....	Haze..	SW. by W.	2	....	...do ...	McNeill.
		14	H. 2-24	67.6	72.3	72.3	68.0	4.3	80.4	30.291	70.8	30.178	0	....	Haze..	WSW.	2	....	...do ...	Libbey.
H. 6, No. 119	40° 22′ 0″ N., 71° 10′ 0″ W.	15	....	67.6	71.8	72.3	67.8	4.5	78.0	30.272	70.7	30.159	0	....	Haze..	SW. by W.	2	....	...do ...	McNeill.
		16	....	72.0	71.8	72.0	67.0	5.0	75.8	30.252	71.2	30.138	0	....	Haze..	WSW.	2	....	...do ...	Do.
		17	....	71.8	71.2	71.2	66.5	4.7	77.6	30.250	71.8	30.134	0	....	Haze..	WSW.	1	....	...do ...	Libbey.
		18	....	71.5	69.2	69.2	65.0	4.2	79.6	30.250	70.8	30.137	1	....	Str ...	SW.	1	....	...do ...	Do.
		19	....	70.3	68.3	68.5	63.7	4.8	74.3	30.250	70.7	30.137	1	....	Str ...	WSW.	1	....	...do ...	Do.
		20	....	70.2	68.3	68.2	63.4	4.8	74.3	30.256	70.1	30.142	0	....	....	SW. by W.	1	....	...do ...	Do.
		21	L. 9-59	70.2	67.9	68.0	63.3	4.7	76.6	30.264	71.1	30.150	0	....	....	SW.	2	....	...do ...	Magie.
H. 7, No. 120	40° 12′ 0″ N., 71° 10′ 0″ W.	22	....	70.3	67.5	68.0	63.8	4.2	79.0	30.288	70.2	30.177	0	....	....	SSW.	2	....	...do ...	Do.
		23	....	70.5	67.8	67.8	64.1	3.7	81.7	30.270	70.0	30.159	0	....	....	SSW.	2	....	...do ...	Do.
		24	....	70.0	67.5	67.8	64.6	3.2	84.1	30.282	70.6	30.169	0	....	....	SW. by S.	2	....	...do ...	Do.

TABLE 23

Date, September 4, 1889. Solar radiation thermometer, 140° F. Maximum temperature, 82° F. Six's, 81.6° F.
Terrestrial radiation thermometer, 64.3° F. Minimum temperature, 65.3° F. Six's, 65° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°	0—10.	Upper.	Lower.	Direction.	Force.			
																		In.		
		1	...	70.2	67.2	67.5	65.1	2.4	86.8	30.280	69.4	30.171	0	...	Haze	N. by W.	2	...	Calm	McNeill.
H. 8, No. 121	40° 2′ 0″ N., 71° 10′ 0″ W.	2	...	69.6	66.3	66.8	64.0	2.8	84.1	30.252	70.0	30.141	0	...	Haze	N. by W.	1	...	...do...	Do.
		3	H. 3–24	69.6	66.4	66.8	64.1	2.7	86.6	30.276	69.6	30.166	0	...	Haze	WSW.	1	...	...do...	Do.
		4	...	70.8	66.5	66.9	64.0	2.9	84.1	30.274	69.4	30.165	0	...	Haze	WSW.	1	...	...do...	Do.
		5	...	70.3	65.7	66.0	62.4	3.6	81.1	30.280	69.4	30.171	0	...	Haze	WSW.	1	...	...do...	Libbey.
		6	...	70.0	66.7	67.0	65.0	2.0	89.3	30.304	64.2	30.195	0	...	Haze	WSW.	1	...	...do...	Do.
		7	...	68.5	67.0	67.2	64.5	2.7	86.6	30.296	69.9	30.186	0	...	Haze	WSW.	1	...	...do...	Do.
		8	...	69.2	68.8	69.4	65.5	3.9	79.6	30.300	70.1	30.189	5	...	Str	WSW.	1	...	...do...	Do.
		9	L. 9–49	70.3	72.5	72.8	67.8	5.0	75.8	30.304	71.5	30.191	1	...	Str	...	0	...	...do...	Magie.
		10	...	71.0	74.1	74.2	68.8	5.4	74.0	30.326	72.0	30.209	0	...	Str	...	0	...	...do...	Do.
		11	...	72.7	74.8	74.8	69.0	5.8	72.4	30.324	72.6	30.206	0	...	Str	...	0	...	...do...	Do.
		12	...	71.7	74.5	74.5	69.5	5.0	76.4	30.322	73.0	30.203	0	...	Str	...	0	...	...do...	Do.
		13	...	71.8	79.5	79.4	71.5	7.9	65.7	30.312	74.6	30.188	0	...	Str	...	0	...	...do...	Libbey.
		*14	...	72.5	81.3	81.0	71.0	10.0	59.0	30.300	74.5	30.176	2	Cir	...	...	0	...	...do...	Do.
		*15	H. 3–25	71.0	79.2	78.8	69.2	9.6	59.6	30.300	74.7	30.176	8	Cir	Str	...	0	...	...do...	Do.
		*16	...	72.8	77.2	77.0	68.5	8.5	62.6	30.296	74.5	30.172	4	Cir	Str	...	0	...	...do...	Do.
		17	...	73.0	73.2	73.2	67.0	6.2	71.6	30.290	75.0	30.165	0	...	...	ESE.	1	...	...do...	Magie.
		18	...	71.3	71.5	71.3	67.2	4.1	80.2	30.292	75.0	30.167	1	...	Str	ESE.	1	...	...do...	Do.
		19	...	72.0	71.2	71.3	69.6	1.7	92.3	30.300	75.5	30.174	0	...	...	ESE.	2	...	...do...	Do.
H. 10, No. 122	39° 42′ 0″ N., 71° 13′ 0″ W.	20	...	72.2	71.6	71.6	70.7	0.9	94.9	30.330	75.0	30.205	0	...	...	SE. by S.	2	...	...do...	Do.
		21	...	70.2	71.2	71.4	70.9	0.5	97.4	30.265	74.8	30.141	0	...	...	ESE.	3	...	...do...	McNeill.
		22	L. 10–53	70.2	71.2	71.2	70.7	0.5	97.4	30.298	74.0	30.176	0	...	...	SE. by S.	3	...	...do...	Do.
H. 11, No. 123	39° 32′ 0″ N., 71° 10′ 0″ W.	23	...	69.9	70.9	71.2	71.0	0.2	100.0	30.325	68.3	30.219	0	...	...	SE.	2	...	...do...	Do.
		24	...	70.2	71.2	71.2	70.9	0.3	98.5	30.315	74.0	30.193	0	...	...	SE. by S.	2	...	...do...	Do.

*Sun on thermometer box.


No. 23
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York...... Boston — — Grampus —
SEPT. 4
TEMPERATURES, AIR AND WATER.
Grampus, Air — Grampus, Water —
Hours of the Day
Deg. Fahr.
GRAMPUS
BOSTON
NEW YORK
AIR
WATER

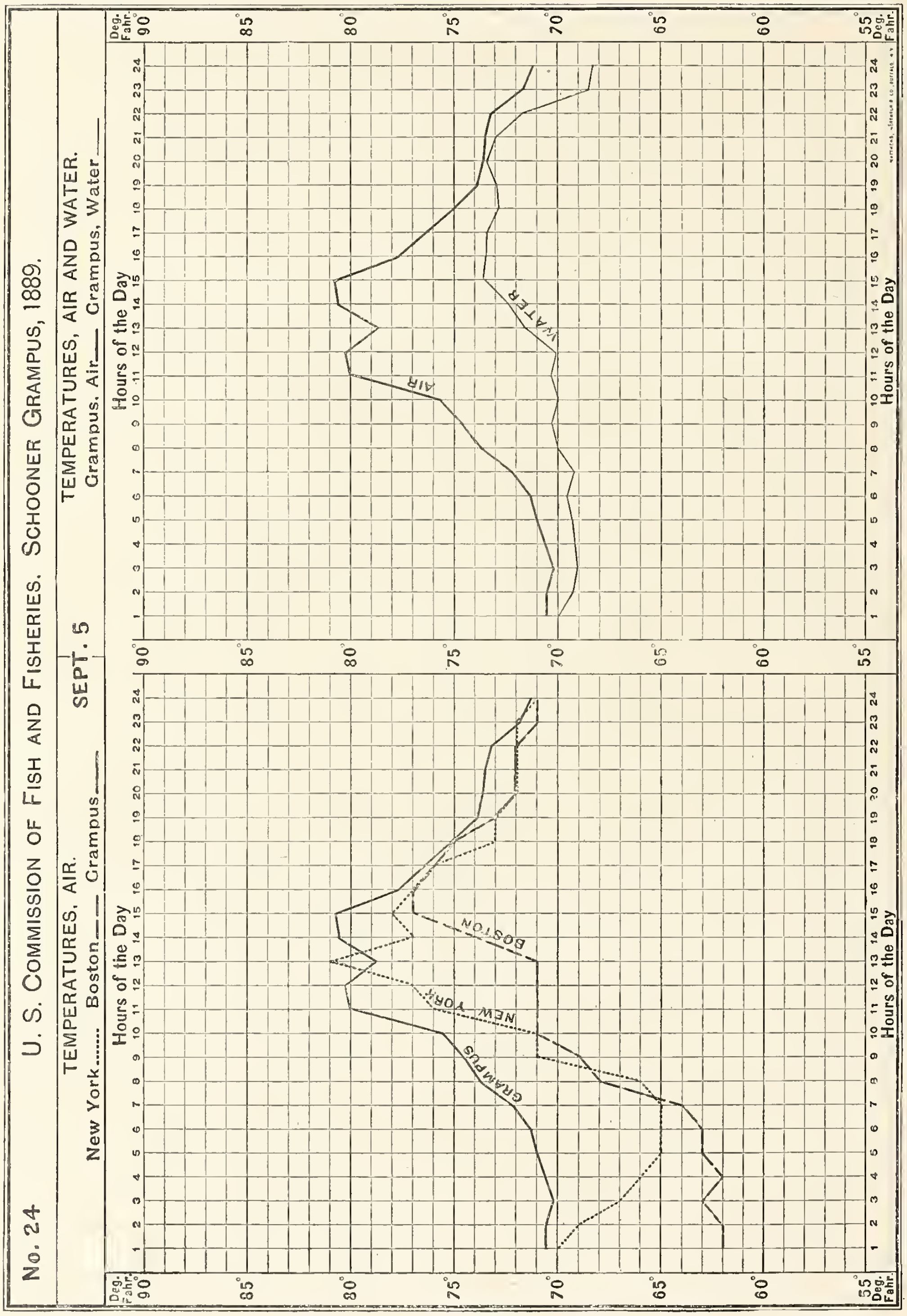

No. 24
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES. AIR.
New York...... Boston.—— Grampus——
SEPT. 5
TEMPERATURES, AIR AND WATER.
Grampus. Air.—— Grampus, Water——
Hours of the Day
Deg. Fahr.
90°
85°
80°
75°
70°
65°
60°
55°
NEW YORK
BOSTON
GRAMPUS
AIR
WATER

TABLE 24.

Date, September 5, 1889. Solar radiation thermometer, 142.7° F. Maximum temperature, 82.9° F. Six's, 82.4° F
Terrestrial radiation thermometer, 64° F. Minimum temperature, 64.7 F. Six's, 64° F.

Station.	Position.	Hour.	Tide.	Temperature. Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Barometer. Reading.	t.	=32°.	Clouds. 0—10.	Upper.	Lower.	Wind. Direction.	Force.	Rain.	State of sea.	Observer.
																		In.		
		1	....	70.0	70.6	70.8	70.6	0.2	100.0	30.290	74.0	30.168	0	....	....	SE.	2	...	Calm ..	Libbey.
		2	....	69.2	70.6	70.7	70.5	0.2	100.0	30.280	73.8	30.159	0	....	....	SE.	3	...	...do ...	Do.
H. 12, No. 124	39° 22′ 0″ N., 71° 10′ 0″ W.	3	....	69.1	70.2	70.3	70.3	0.0	100.0	30.288	74.0	30.166	0	....	....	SE.	2	..	...do ...	Do.
		4	H. 4-20	69.2	70.6	70.8	70.8	0.0	100.0	30.284	74.0	30.162	2	....	Str.....	SE.	1	...	...do ...	Do.
		5	....	69.3	71.0	71.0	71.0	0.0	100.0	30.286	73.0	30.167	3	....	Str.....	SE.	2	...	.. do ...	Magie.
G. 12, No. 125	39° 29′ 0″ N., 71° 5′ 0″ W.	6	....	69.5	71.3	71.3	71.2	0.1	100.0	30.302	74.3	30.180	2	....	Str.....	SE.	2	...	.. do ...	Do.
		7	....	69.2	72.1	72.1	72.1	0.0	100.0	30.310	74.0	30.188	3	....	Cir. str.	SE.	2	...	.. do ..	Do.
		8	....	70.0	73.9	73.9	73.5	0.4	98.0	30.306	74.2	30.184	5	....	Cir. cu .	SE.	2	...	.. do ...	Do.
G. 11, No. 126	39° 39′ 0″ N., 71° 5′ 0″ W.	9	....	70.3	74.6	74.9	73.6	1.3	92.7	30.300	75.0	30.175	9	....	Cir. cu .	SSE.	3	...	...do ...	McNeill.
		*10	L. 10-47	70.0	75.6	75.9	74.0	1.9	90.6	30.305	75.2	30.180	2	Cir. str.	....	SSE.	3	...	...do ...	Do.
		*11	... .	70.4	80.0	80.2	76.1	4.1	82.4	30.302	76.0	30.175	1	Cir. str.	....	SE.	3	...	..do ...	Do.
G. 10, No. 127	39° 49′ 0″ N., 71° 3′ 0″ W.	*12	....	70.1	80.3	80.3	76.1	4.2	82.4	30.304	77.2	30.174	0	....	....	SE.	3	...	.. do ...	Do.
		*13	....	71.5	78.7	78.4	75.0	3.4	84.2	30.300	77.5	30.169	0	....	....	SSE.	3	†.50	...do ...	Magie.
G. 9, No. 128	39° 52′ 0″ N., 71° 0′ 0″ W.	*14	....	72.3	80.6	80.6	76.8	3.8	82.4	30.292	78.0	30.159	0	....	....	SSE.	3	...	...do ...	Do.
		*15	....	73.5	80.8	80.8	76.5	4.3	80.4	30.280	77.5	30.148	0	....	....	SSE	3	...	...do ...	Do.
		16	H. 4-20	73.4	77.6	77.5	75.0	2.5	88.5	30.274	77.0	30.144	0	....	....	SSE.	3	...	...do ...	Do.
G. 8, No. 129	40° 2′ 0″ N., 71° 2′ 0″ W.	17	....	73.3	76.2	76.1	75.0	1.1	95.2	30.276	77.4	30.142	0	....	....	SSE.	3	...	...do ...	McNeill.
		18	....	72.8	74.9	75.0	73.9	1.1	95.1	30.278	76.2	30.151	0	....	....	SSE.	3	...	...do ...	Do.
G. 7, No. 130	40° 13′ 0″ N., 71° 1′ 30″ W.	19	....	72.9	73.9	74.1	73.8	0.3	97.5	30.302	76.0	30.175	0	....	....	SSE.	3	...	...do ...	Do.
		20	....	73.3	73.6	73.9	73.8	0.1	100.0	30.298	75.5	30.172	0	....	....	S.	3	...	...do ...	Do.
G. 6, No. 131	40° 22′ 0″ N., 71° 1′ 0″ W.	21	....	73.0	73.5	73.7	73.2	0.5	97.5	30.284	75.8	30.158	0	....	....	S.	4	..	Mod. sw.	Libbey.
		22	....	71.7	73.2	73.4	73.0	0.4	97.5	30.286	75.0	30.161	0	....	....	S.	5	...	...do ..	Do.
		23	L. 11-42	68.6	71.8	72.0	71.5	0.5	97.5	30.282	74.2	30.160	0	....	....	S.	4	...	...do ...	Do.
G. 5, No. 132	40° 32′ 0″ N., 71° 0′ 0″ W.	24	....	68.3	71.2	71.4	71.2	0.2	100.0	30.276	74.0	30.154	0	....	....	S.	3	...	...do ...	Do.

* Sun on thermometer box.

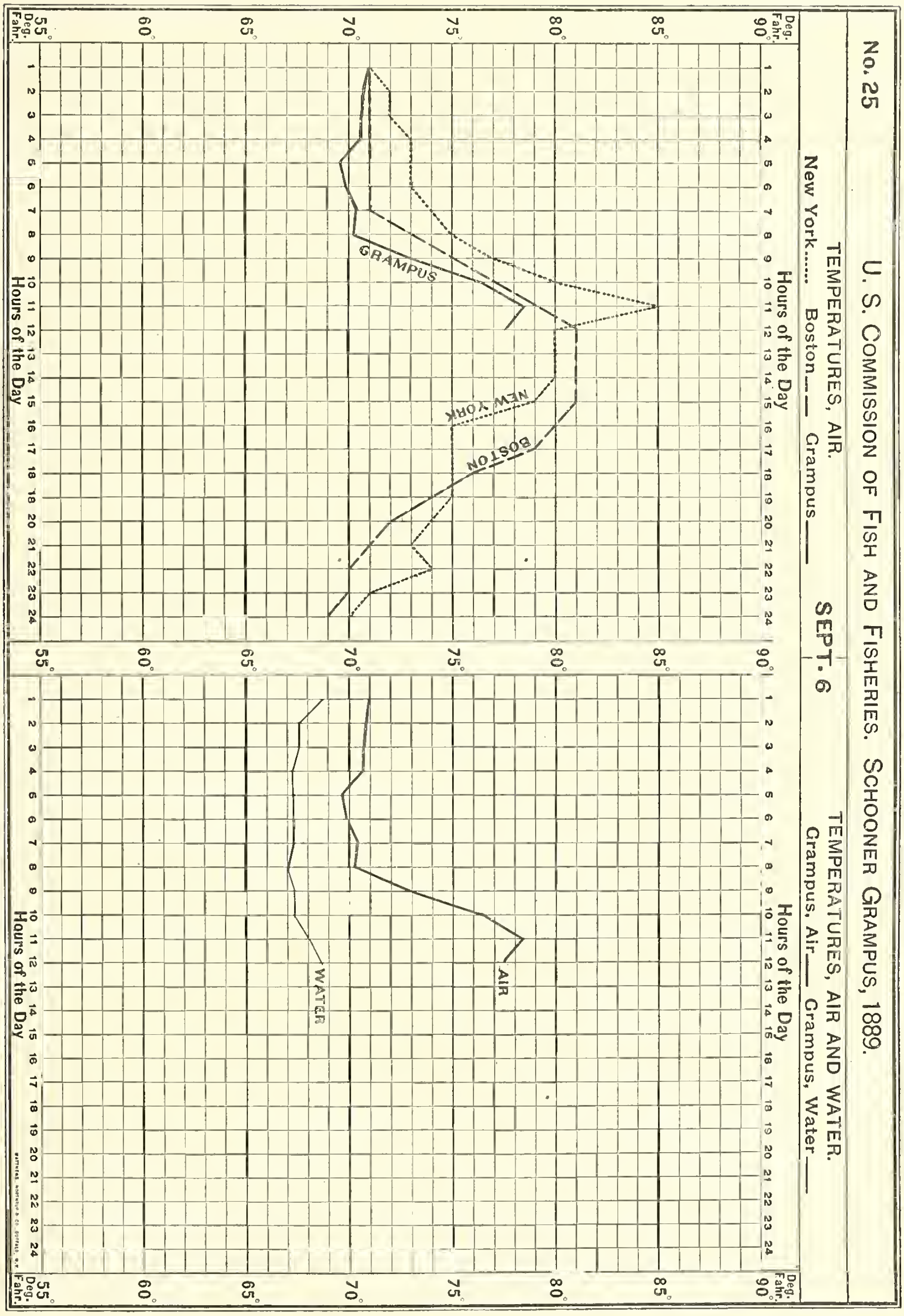
† Evaporation.

TABLE 25.

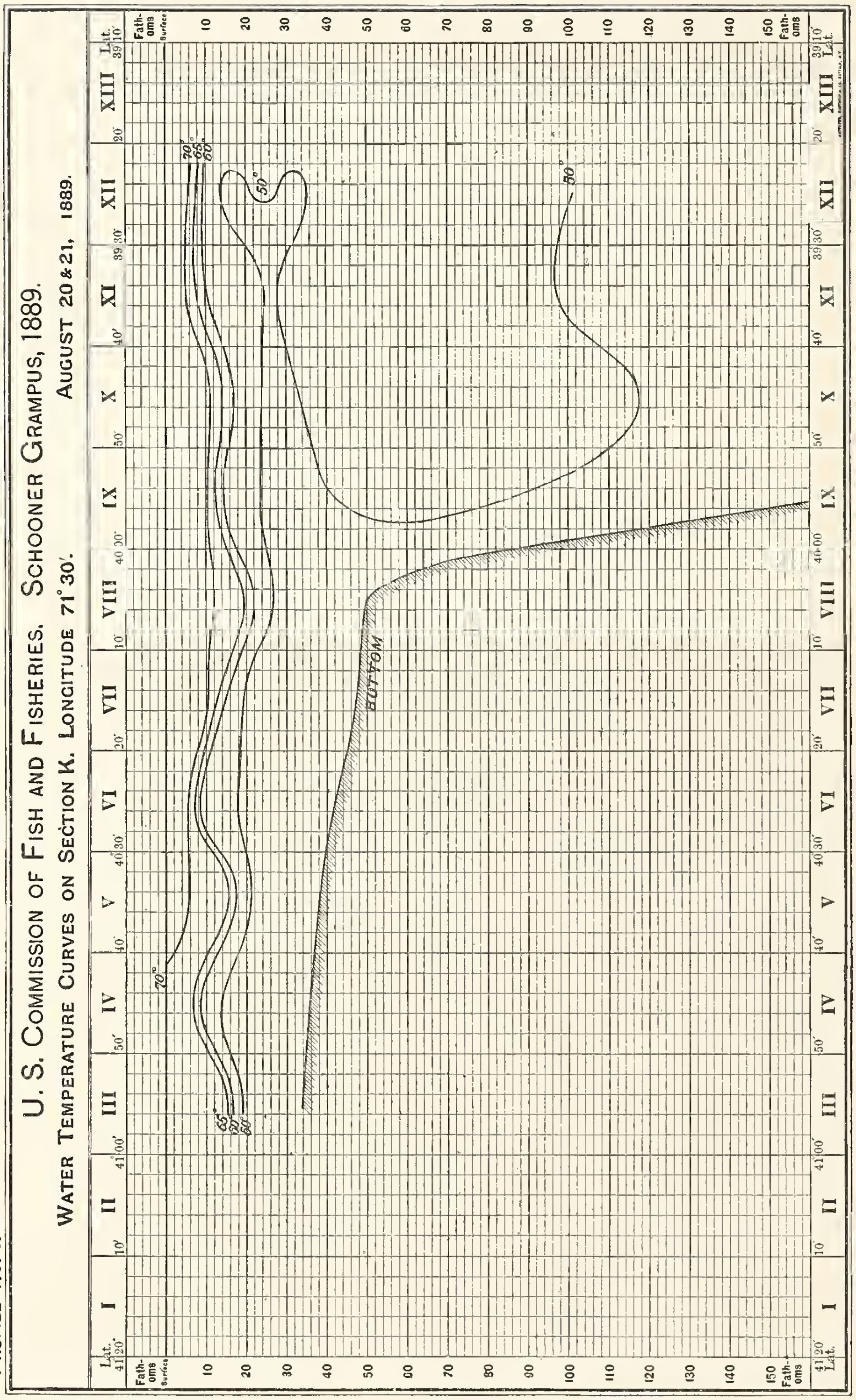
Date, September 6, 1889. Solar radiation thermometer, 129° F. Maximum temperature, 79.6° F. Six's, 80° F.
Terrestrial radiation thermometer, 67° F. Minimum temperature, 68.8° F. Six's, 69.5° F.

Station.	Position.	Hour.	Tide.	Temperature.						Barometer.			Clouds.			Wind.		Rain.	State of sea.	Observer.
				Water.	Air.	Dry bulb.	Wet bulb.	Difference.	Relative humidity.	Reading.	t.	=32°.	0—10.	Upper.	Lower.	Direction.	Force.	In.		
G. 4, No. 133	40° 42′ 0″ N., 71° 0′ 0″ W.	1	....	68.8	71.0	71.0	70.6	0.4	97.4	30.254	73.7	30.133	0	....	....	S. by W.	3	....	Calm ..	Magie.
		2	....	67.6	70.9	71.0	71.0	0.0	100.0	30.232	74.0	30.110	0	....	....	S. by W.	3	....	...do ...	Do.
		3	....	67.5	70.6	70.6	70.6	0.0	100.0	30.232	73.0	30.113	0	....	....	S. by W.	3	....	...do ...	Do.
		4	....	67.2	70.5	70.0	70.0	0.0	100.0	30.230	72.8	30.112	0	....	....	S. by W.	2	....	...do ...	Do.
G. 3, No. 134	40° 51′ 0″ N., 71° 0′ 0″ W.	5	H. 5–9	67.2	69.5	69.9	69.9	0.0	100.0	30.228	73.7	30.107	0	....	Str ...	S.	2	....	...do ...	McNeill.
		6	....	67.2	69.8	70.0	70.0	0.0	100.0	30.241	73.0	30.122	0	....	....	S.	2	....	...do ...	Do.
		7	....	67.2	70.3	70.7	70.7	0.0	100.0	30.250	73.0	30.131	0	....	....	S.	2	....	...do ...	Do.
G. 2, No. 135	41° 0′ 0″ N., 71° 0′ 0″ W.	8	....	67.0	70.2	70.4	70.0	0.4	97.4	30.238	73.0	30.119	0	....	....	S.	2	....	...do ...	Do.
		*9	....	67.2	73.0	73.0	72.3	0.7	95.0	30.278	74.5	30.155	0	....	....	S.	2	....	...do ...	Libbey.
		*10	....	67.3	76.4	76.7	74.7	2.0	90.6	30.260	75.0	30.135	0	....	....	S.	2	....	...do ...	Do.
		*11	L. 11–40	68.0	78.5	78.4	74.0	4.4	79.9	30.264	76.2	30.137	0	....	....	S.	2	....	...do ...	Do.
G. 2, No. 136*	41° 9′ 0″ N., 71° 0′ 0″ W.	12	....	68.5	77.4	77.4	73.9	3.5	83.8	30.252	76.3	30.125	0	....	....	S.	2	†.12	...do ...	Do.
		13	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		14	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		15	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		16	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		17	H. 5–14	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		18	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		19	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		20	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		21	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		22	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		23	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	
		24	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	....	....	....	..	....	....	

* Sun on thermometer box. † Evaporation.


No. 25
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
TEMPERATURES, AIR.
New York..... Boston.— Grampus—
SEPT. 6
TEMPERATURES, AIR AND WATER.
Grampus, Air— Grampus, Water—
Hours of the Day
Deg. Fahr.
GRAMPUS
NEW YORK
BOSTON
AIR
WATER

Profile No. 1.


U. S. Commission of Fish and Fisheries. Schooner Grampus, 1889.
Water Temperature Curves on Section K. Longitude 71°30'. August 20 & 21, 1889.
Lat.
41°20'
I
10'
II
41°00'
III
50'
IV
40'
V
40°30'
VI
20'
VII
10'
VIII
40°00'
IX
50'
X
40'
XI
39°30'
XII
20'
XIII
39°10'
Fathoms
Surface
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
70°
65°
60°
50°
BOTTOM

Explanation of Profile No. 1.—Water Temperature Curves on Line K.

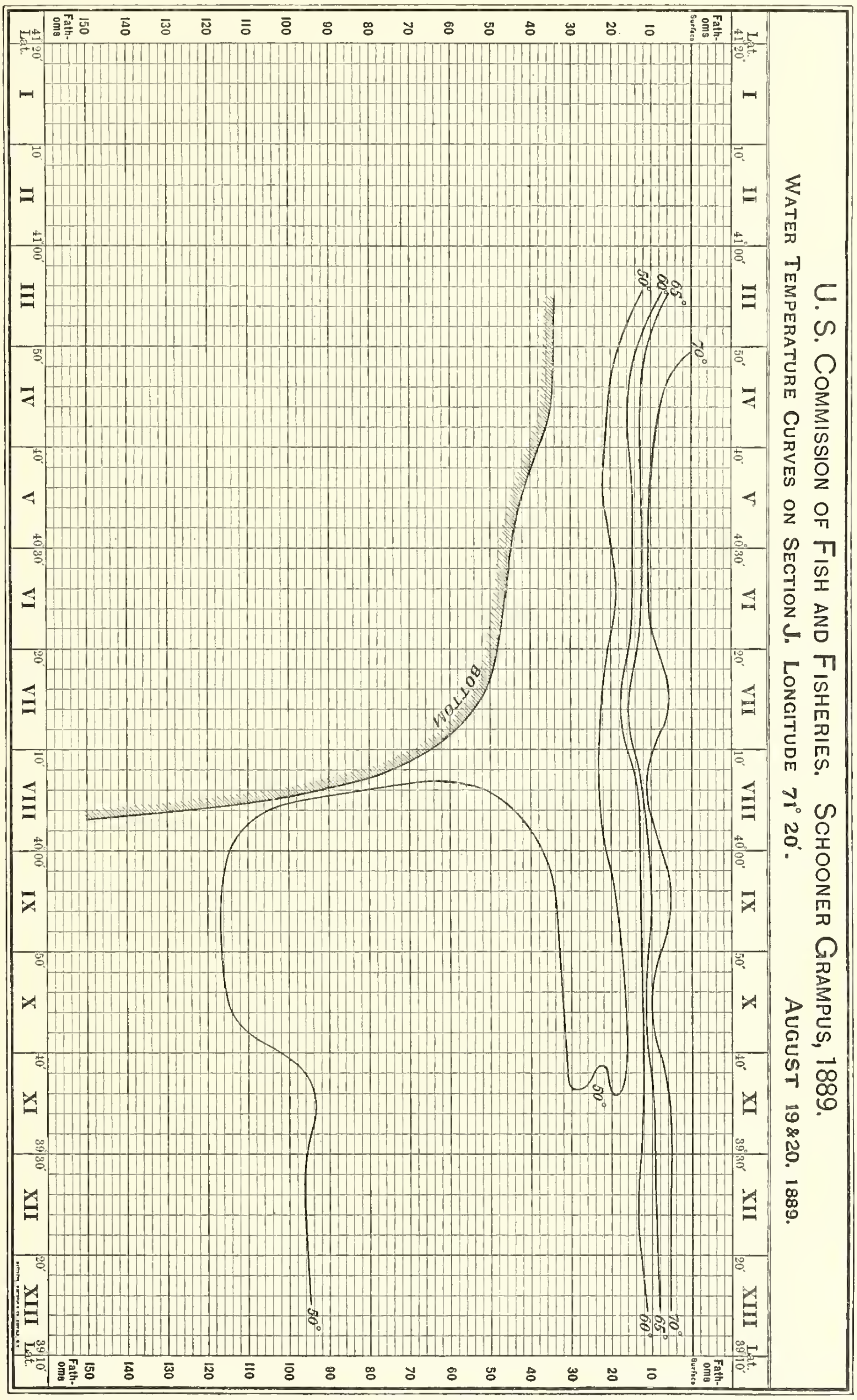
The Roman numerals at the top and bottom of the plate represent the corresponding spaces on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	STATIONS.												
	I.	II.	III. Depth 34 fath.	IV. Depth 35 fath.	V. Depth 38 fath.	VI. Depth 40 fath.	VII. Depth 47 fath.	VIII. Depth 50 fath.	IX. Depth 150 fath.	X.	XI.	XII.	XIII.
0	....	....	69.2	69.9	71.4	71.8	71.9	71.8	71.3	72.3	72.4	74.8	....
5	....	....	69.4	68.7	70.4	71.5	71.7	70.9	70.9	71.9	70.7	72.2	....
10	....	....	68.0	55.3	68.0	53.5	70.9	70.9	71.1	71.9	60.5	58.9	....
15	....	....	67.0	48.4	67.8	50.4	59.2	68.7	57.9	64.0	54.0	47.2	....
20	....	....	45.4	45.4	51.2	49.7	48.1	64.4	60.2	55.1	52.3	49.6	....
25	....	....	45.3	44.4	45.2	46.0	46.3	51.5	45.4	48.6	49.8	51.1	....
30	....	....	44.4	44.4	44.4	46.1	45.4	46.9	49.6	49.1	50.2	49.1	....
40	....	....	....	....	....	44.9	44.8	45.9	49.1	52.2	52.6	50.8	....
50	....	....	....	....	....	....	....	48.6	53.0	54.0	54.5	52.8	....
75	....	....	....	....	....	....	....	....	52.1	53.8	53.5	53.1	....
100	....	....	....	....	....	....	....	....	46.4	51.7	49.7	50.1	....
150	....	....	....	....	....	....	....	....	44.7	46.8	46.8	45.5	....
200	....	....	....	....	....	....	....	....	....	43.9	44.3	43.2	....
250	....	....	....	....	....	....	....	....	....	41.5	41.6	41.6	....
300	....	....	....	....	....	....	....	....	....	40.0	40.5	40.2	....
400	....	....	....	....	....	....	....	....	....	39.5	39.7	39.5	....
500	....	....	....	....	....	....	....	....	....	39.2	39.7	39.0	....
Bottom	....	....	44.7	43.9	44.3	44.9	45.9	48.6	44.7	....	....	....	....

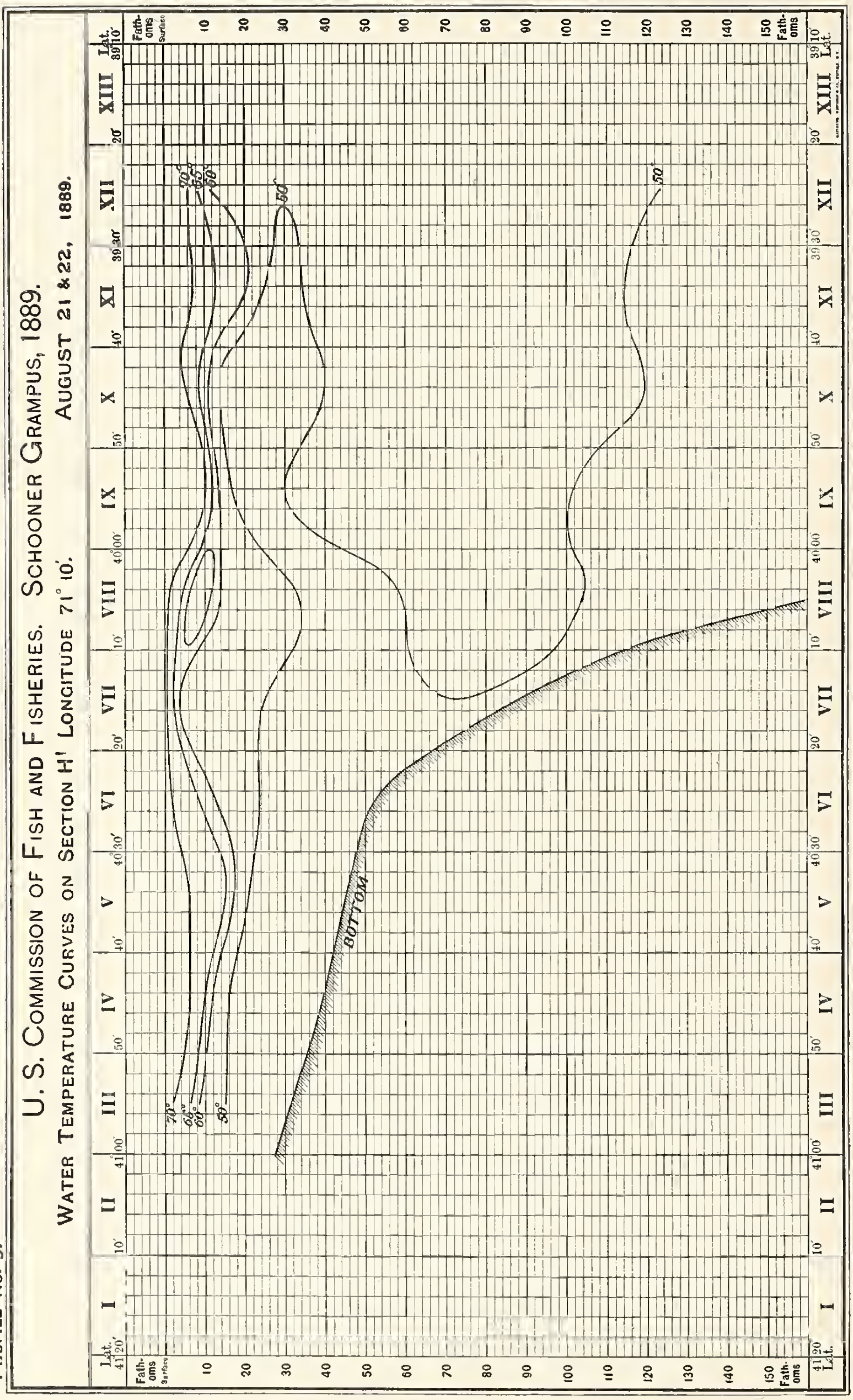
EXPLANATION OF PROFILE NO. 2.—WATER TEMPERATURE CURVES ON LINE J.

The Roman numerals at the top and bottom of the plate represent the corresponding spaces on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	STATIONS.												
	I.	II.	III. Depth 34 fath.	IV. Depth 35 fath.	V. Depth 42 fath.	VI. Depth 46 fath.	VII. Depth 52 fath.	VIII. Depth 102 fath.	IX. Depth 380 fath.	X.	XI.	XII.	XIII.
0	....	....	68.8	70.5	71.2	71.0	71.2	71.0	71.5	72.0	72.3	71.5	71.0
5	....	....	68.7	70.3	70.9	70.7	70.7	70.7	71.0	71.2	71.8	71.6	71.4
10	....	....	52.3	69.7	70.9	71.3	67.3	71.2	64 9	71.7	64.6	63.1	61.9
15	....	....	48.0	61.7	60.0	71.0	67.9	54.3	57.6	52.0	55.5	58.6	55.0
20	....	....	46.8	50.2	52.0	48.2	54.2	57.5	47.4	46.9	51.7	55.6	49.8
25	....	....	45.2	48.2	47.8	46.4	45.9	45.9	47.8	47.1	52.2	55.0	49.8
30	....	....	....	47.8	51.0	45.9	46.8	45.8	48.2	49.4	51.9	54.7	49.7
40	....	....	....	....	44.5	44.2	47.3	46.9	52.5	51.8	53.9	53.0	52.5
50	....	....	....	....	....	....	47.2	50.9	53.5	55.2	54.3	53.6	53.2
75	....	....	....	....	....	....	....	52.0	52.8	53.9	52.0	53.2	53.1
100	....	....	....	....	....	....	....	49.8	52.2	51.2	49.4	49.5	49.3
150	....	....	....	....	....	....	....	....	53.2	47.1	47.3	44.6	45.7
200	....	....	....	....	....	....	....	....	43.9	44.8	44.7	42.6	44.2
250	....	....	....	....	....	....	....	....	41.8	42.0	41.3	41.8	41.7
300	....	....	....	....	....	....	....	....	40.0	40.6	40.5	40.3	40.0
400	....	....	....	....	....	....	....	....	....	39.5	39.3	39.4	39.6
500	....	....	....	....	....	....	....	....	....	39.2	39.1	39.1	39.2
Bottom	....	....	45.1	47.8	44.5	44.2	47.2	49.8	39.6	....	....	....	....


PROFILE No. 2.
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
WATER TEMPERATURE CURVES ON SECTION J. LONGITUDE 71° 20'.
AUGUST 19 & 20. 1889.
BOTTOM
Lat. 41° 20'
Lat. 39° 10'
Fathoms
Surface
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
70°
65°
60°
50°

PROFILE No. 3.


U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
WATER TEMPERATURE CURVES ON SECTION H' LONGITUDE 71° 10'.
AUGUST 21 & 22, 1889.
BOTTOM
70°
65°
60°
50°
Lat.
Fathoms
Surface
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII

EXPLANATION OF PROFILE NO. 3.—WATER TEMPERATURE CURVES ON LINE H[1].

The Roman numerals at the top and bottom of the plate represent the corresponding spaces on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	STATIONS.												
	I.	II.	III. Depth 32 fath.	IV. Depth 39 fath.	V. Depth 45 fath.	VI. Depth 52 fath.	VII. Depth 87 fath	VIII. Depth 160 fath.	IX. Depth 453 fath.	X.	XI.	XII.	XIII.
0	......	......	70.6	72.8	73.2	72.0	71.8	70.8	72.0	72.9	73.4	74.2	......
5	......	......	69.3	71.4	71.0	67.9	56.9	64.4	71.0	71.7	70.8	71.3	......
10	......	......	55.9	64.9	67.6	63.9	55.0	67.0	70.3	62.7	69.0	62.2	......
15	......	......	50.7	51.3	65.2	57.2	52.0	58.0	52.1	47.1	60.5	55.5	......
20	......	......	46.1	46.8	50.7	56.0	51.5	57.0	47.5	45.8	60.8	53.7	......
25	......	......	44.9	44.9	46.9	47.8	50.0	52.2	47.9	46.6	47.7	52.0	......
30	......	......	45.3	44.1	46.1	46.8	47.4	55.5	49.9	49.0	48.8	51.9	......
40	......	......	......	......	45.4	45.3	46.7	48.5	56.8	49.9	51.5	53.1	......
50	......	......	......	......	......	44.9	47.0	47.3	55.4	54.2	53.7	54.4	......
75	......	......	......	......	......	......	50.7	54.7	53.1	54.3	54.0	53.8	......
100	......	......	......	......	......	......	......	50.3	50.1	52.0	51.2	52.8	......
150	......	......	......	......	......	......	......	46.4	45.1	46.7	47.4	47.8	......
200	......	......	......	......	......	......	......	......	43.3	45.0	44.7	42.9	......
250	......	......	......	......	......	......	......	......	40.8	42.1	41.7	41.2	......
300	......	......	......	......	......	......	......	......	39.7	40.9	40.4	40.9	......
400	......	......	......	......	......	......	......	......	39.7	39.9	39.7	40.1	......
500	......	......	......	......	......	......	......	......	......	39.4	39.3	39.3	......
Bottom	......	......	45.3	45.2	45.4	44.9	50.7	46.4	39.7	......	......	......	......

EXPLANATION OF PROFILE NO. 4.—WATER TEMPERATURE CURVES ON LINE G[1].

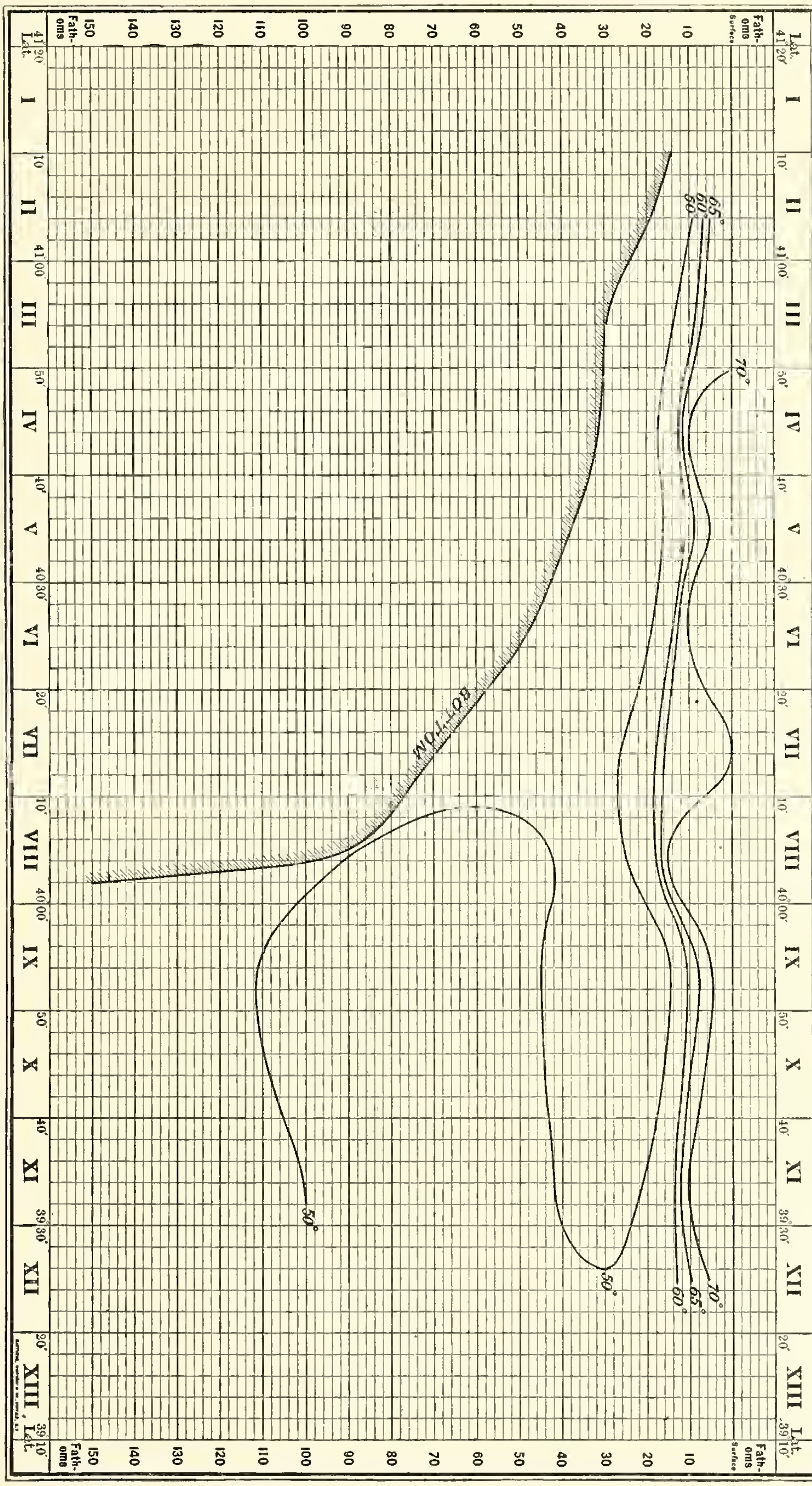
The Roman numerals at the top and bottom of the plate represent the corresponding spaces on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	STATIONS.												
	I.	II. Depth 18 fath.	III. Depth 29 fath.	IV. Depth 31 fath.	V. Depth 38 fath.	VI. Depth 48 fath.	VII. Depth 67 fath.	VIII. Depth 90 fath.	IX. Depth 300 fath.	X.	XI.	XII.	XIII.
0		68.2	69.3	70.4	71.2	70.2	70.0	70.0	70.4		73.2	73.2	
5		69.2	68.7	70.2	70.9	70.7	69.5	70.8	70.2		71.8	71.0	
10		49.8	57.4	70.1	62.8	70.4	68.7	70.6	62.3		71.8	64.7	
15		49.6	48.3	52.0	50.9	58.3	65.9	70.6	49.8		56.5	57.8	
20			47.0	48.0	47.8	48.6	53.7	54.7	45.1		50.9	51.4	
25				45.4	46.6	59.6	50.5	50.1	45.1		46.3	50.8	
30					45.9	48.1	46.6	46.8	47.8		47.8	51.0	
35													
40						46.6	46.4	49.3	49.0		48.2	52.8	
50							47.3	52.0	50.8		54.6	54.2	
75								53.8	53.3		54.6	53.5	
100									51.0		50.1	50.0	
150									45.9		46.9	45.4	
200									43.9		45.6	43.2	
250									40.9			41.7	
300									39.8		40.5	40.7	
400											39.4	39.5	
500											38.9	39.1	
Bottom		49.6	47.0	45.4	44.9	45.4	44.4	51.0	39.8				

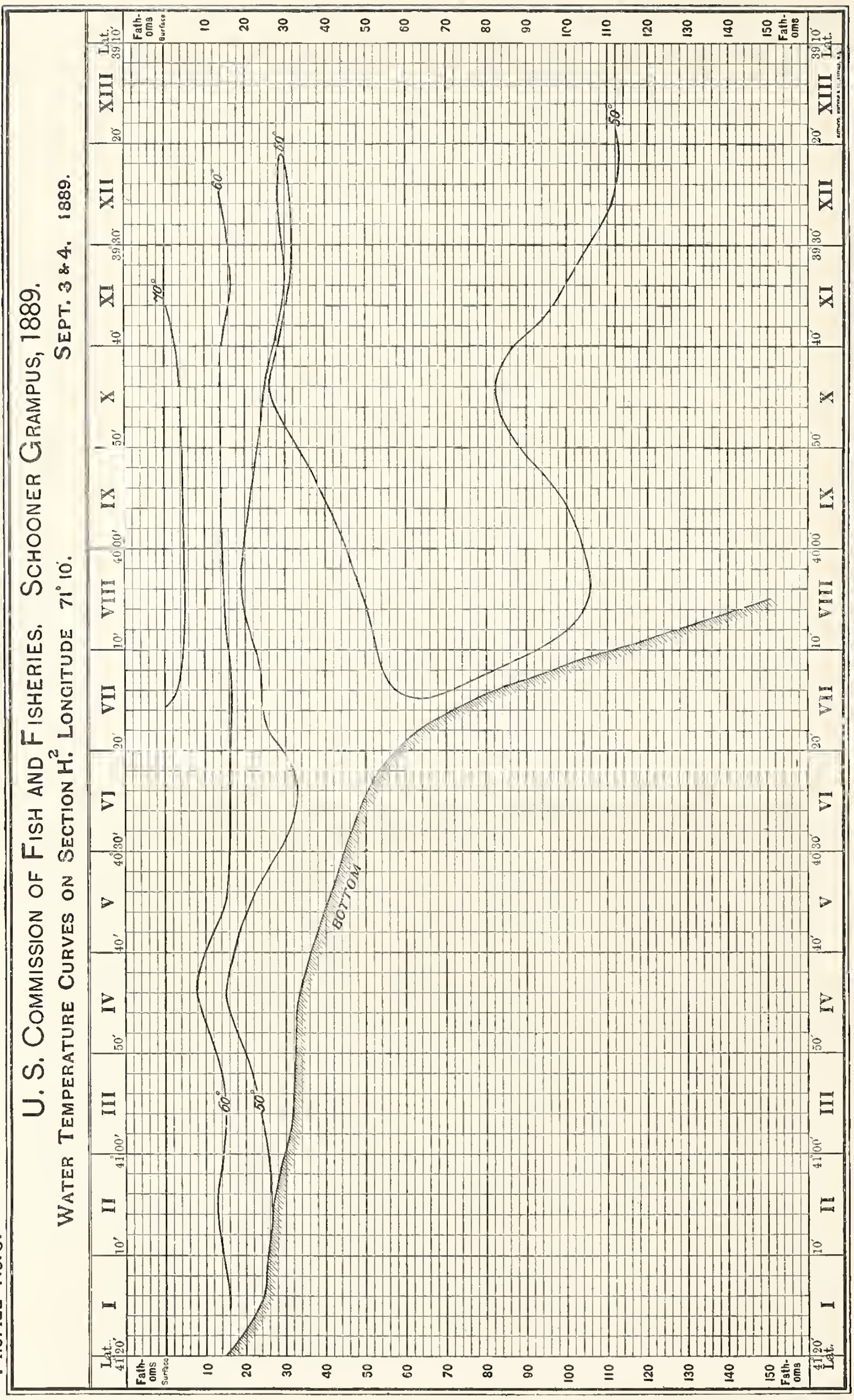
PROFILE No. 4.

U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.

WATER TEMPERATURE CURVES ON SECTION G' LONGITUDE 71° 00'. AUGUST 17 & 18, 1889.



PROFILE No. 5.


U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
WATER TEMPERATURE CURVES ON SECTION H². LONGITUDE 71° 10'.
SEPT. 3 & 4. 1889.
Lat. 41° 20'
I
10'
II
41° 00'
III
50'
IV
40'
V
40° 30'
VI
20'
VII
10'
VIII
40° 00'
IX
50'
X
40'
XI
39° 30'
XII
20'
XIII
39° 10' Lat.
Fathoms
Surface
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150 Fathoms
70°
60°
50°
BOTTOM

EXPLANATION OF PROFILE No. 5.—WATER TEMPERATURE CURVES ON LINE H^2.

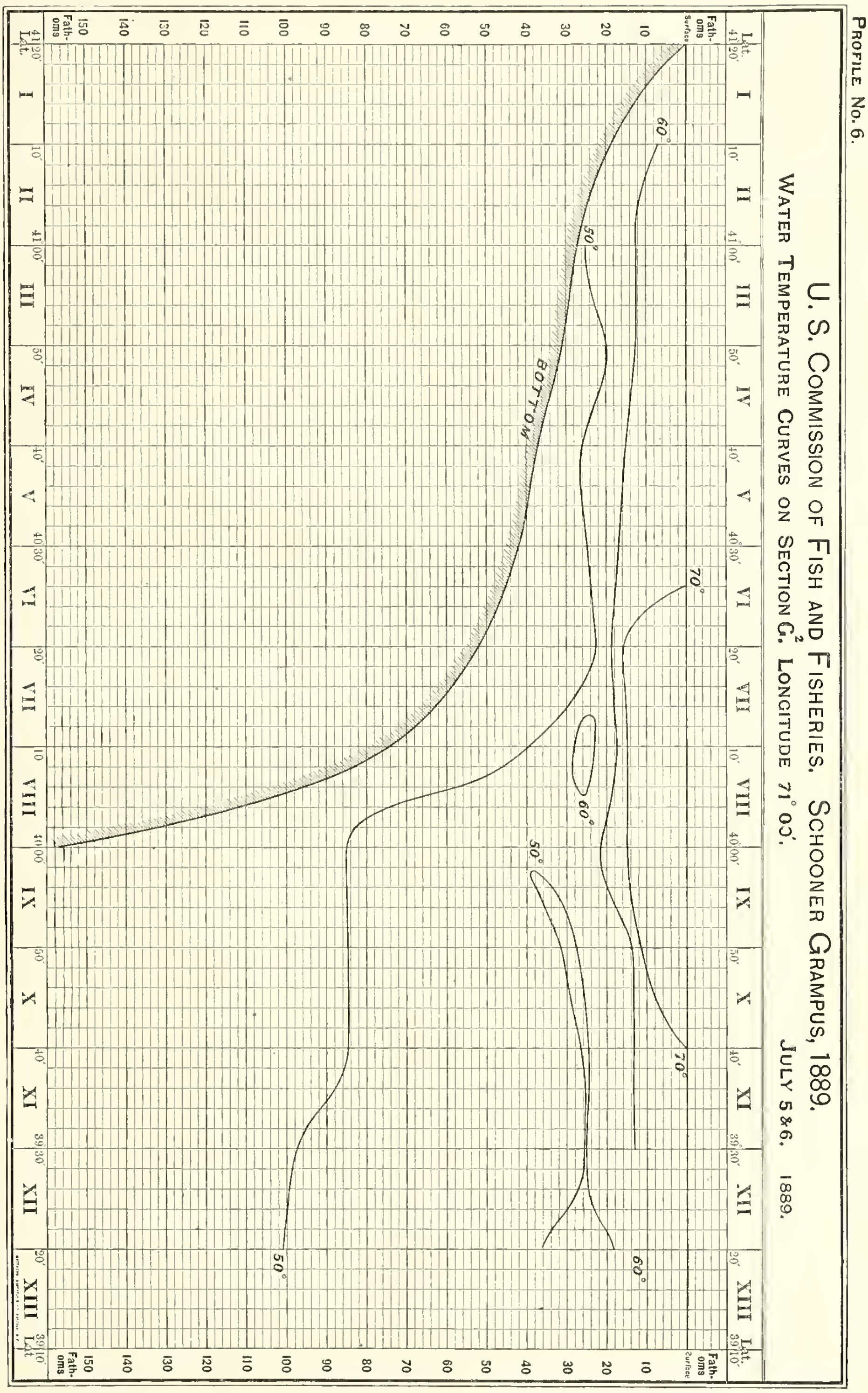
The Roman numerals at the top and bottom of the plate represent the corresponding spaees on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	STATIONS.												
	I. Depth 23 fath.	II. Depth 27 fath.	III. Depth 32 fath.	IV. Depth 33 fath.	V. Depth 40½ fath.	VI. Depth 49 fath.	VII. Depth 76 fath.	VIII. Depth 151 fath.	IX.	X.	XI.	XII.	XIII.
0	65.2	65.5	65.1	65.7	67.8	67.6	70.2	69.6	....	72.2	69.9	69.1	....
5	64.0	64.7	65.3	65.9	66.3	66.7	69.7	70.0	....	69.5	69.8	68.8	....
10	62.6	64.4	63.9	56.6	65.6	67.5	70.2	66.0	....	68.0	68.5	68.8	....
15	61.2	57.0	60.1	50.2	60.2	65.7	64.9	60.2	....	57.9	61.9	57.6	....
20	56.0	54.8	52.0	48.2	50.4	57.1	53.8	48.1	....	54.0	56.8	54.5	....
25	....	51.5	49.2	47.5	48.4	54.9	49.1	47.7	....	49.8	51.8	50.5	....
30	....	....	47.3	46.7	46.7	51.8	48.9	46.2	....	52.0	50.1	49.7	....
40	....	....	....	....	46.3	45.1	46.5	46.8	....	55.1	54.7	53.8	....
50	....	....	....	....	....	....	49.0	50.0	....	53.8	55.6	54.3	....
75	....	....	....	....	....	....	50.6	51.7	....	51.0	52.8	53.9	....
100	....	....	....	....	....	....	....	50.5	....	47.5	49.9	51.0	....
150	....	....	....	....	....	....	....	45.8	....	46.8	54.0	46.5	....
200	....	....	....	....	....	....	....	....	....	42.1	44.2	43.9	....
250	....	....	....	....	....	....	....	....	....	40.6	42.0	41.2	....
300	....	....	....	....	....	....	....	....	....	39.8	40.1	40.3	....
400	....	....	....	....	....	....	....	....	....	39.7	40.0	39.8	....
500	....	....	....	....	....	....	....	....	....	38.8	39.2	39.3	....
Bottom	56.0	51.5	47.3	46.7	46.3	45.7	50.6	45.8	....	....	....	....	....

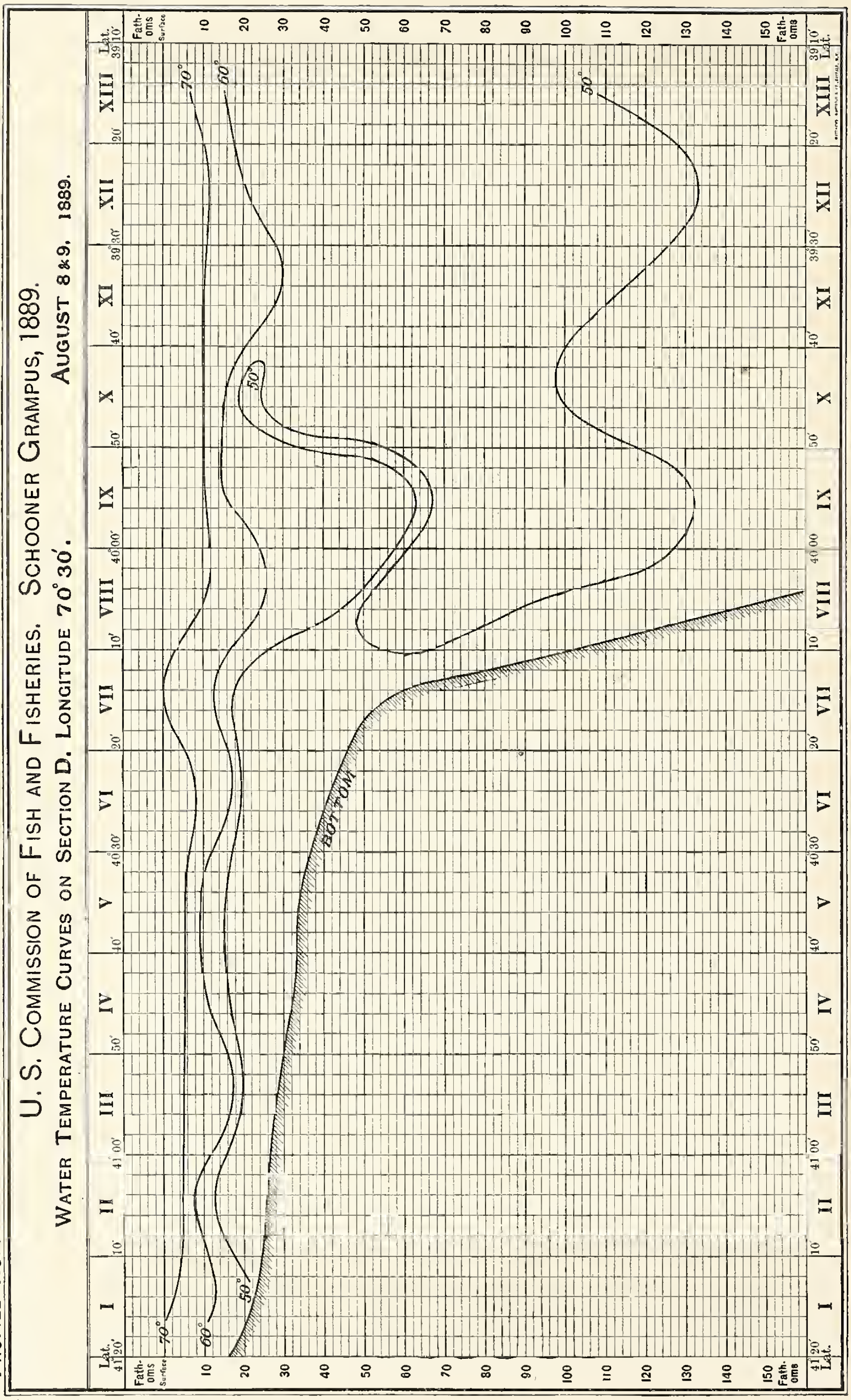
Explanation of Profile No. 6.—Water Temperature Curves on Line G².

The Roman numerals at the top and bottom of the plate represent the corresponding spaces on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	Stations.												
	I. Depth 19 fath.	II. Depth 27 fath.	III. Depth 31 fath.	IV. Depth 37 fath.	V. Depth 41 fath.	VI. Depth 52 fath.	VII. Depth 74 fath.	VIII. Depth 157 fath.	IX. Depth 472 fath.	X.	XI.	XII.	XIII.
0	68.0	67.0	67.1	67.6	68.5	73.0	72.9	73.3	72.3	70.1	70.3	69.5	....
5	63.0	65.9	66.1	67.4	68.2	72.7	71.7	72.0	71.9	68.7	69.0	69.4	....
10	56.3	64.2	64.2	67.1	67.5	72.8	73.0	73.0	72.3	69.0	68.6	69.8	....
15	56 0	56.4	55.8	60.4	65.1	72.8	69.8	71.0	57.6	55.6	56.2	54.0	....
20	....	52.1	49.4	52.0	54.0	55.8	51.0	61.6	53.3	53.0	52.5	46.6	....
25	....	49.9	49.4	50.3	49.8	47.8	66.0	57.2	50.4	49.8	50.4	47.4	....
30	....	....	....	48.5	48.1	47.1	55.9	57.1	49.6	50.4	57.7	48.7	....
40	....	....	....	....	46.5	47.7	49.5	51.9	51.8	53.3	56.2	50.9	....
50	....	....	....	....	....	46.7	54.0	52.9	53.8	53.1	55.8	53.0	....
75	....	....	....	....	....	....	....	51.0	51.1	51.3	52.8	53.1	....
100	....	....	....	....	....	....	....	48.5	48.1	48.3	49.8	50.1	....
150	....	....	....	....	....	....	....	45.7	45.9	44.0	45.9	45.9	....
200	....	....	....	....	....	....	....	....	44.9	41.6	42.6	43.6	....
250	....	....	....	....	....	....	....	....	41.3	40.6	40.9	41.5	....
300	....	....	....	....	....	....	....	....	40.7	39.7	39.8	40.1	....
400c	....	....	....	....	....	....	....	....	39.6	39.4	39.7	39.7	....
500	....	....	....	....	....	....	....	....	....	39.0	39.0	39.0	....
Bottom	56.0	49.9	45.7	46.2	46.5	46.7	49.4	45.7	39.6	....	....	....	....


PROFILE No. 6.
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
WATER TEMPERATURE CURVES ON SECTION G.² LONGITUDE 71° 00'.
JULY 5 & 6. 1889.
Lat.
41°20'
I
10'
II
41°00'
III
50'
IV
40'
V
40°30'
VI
20'
VII
10'
VIII
40°00'
IX
50'
X
40'
XI
39°30'
XII
20'
XIII
39°10'
Fathoms
Surface
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
BOTTOM
60°
50°
70°
60°
50°
70°
60°
50°

PROFILE No. 7.


U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
WATER TEMPERATURE CURVES ON SECTION D. LONGITUDE 70° 30′.
AUGUST 8 & 9. 1889.
Lat. 41°20′
I
10′
II
41°00′
III
50′
IV
40′
V
40°30′
VI
20′
VII
10′
VIII
40°00′
IX
50′
X
40′
XI
39°30′
XII
20′
XIII
39°10′ Lat.
Fathoms Surface
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150 Fathoms
70°
60°
50°
BOTTOM

EXPLANATION OF PROFILE No. 7.—WATER TEMPERATURE CURVES ON LINE D.

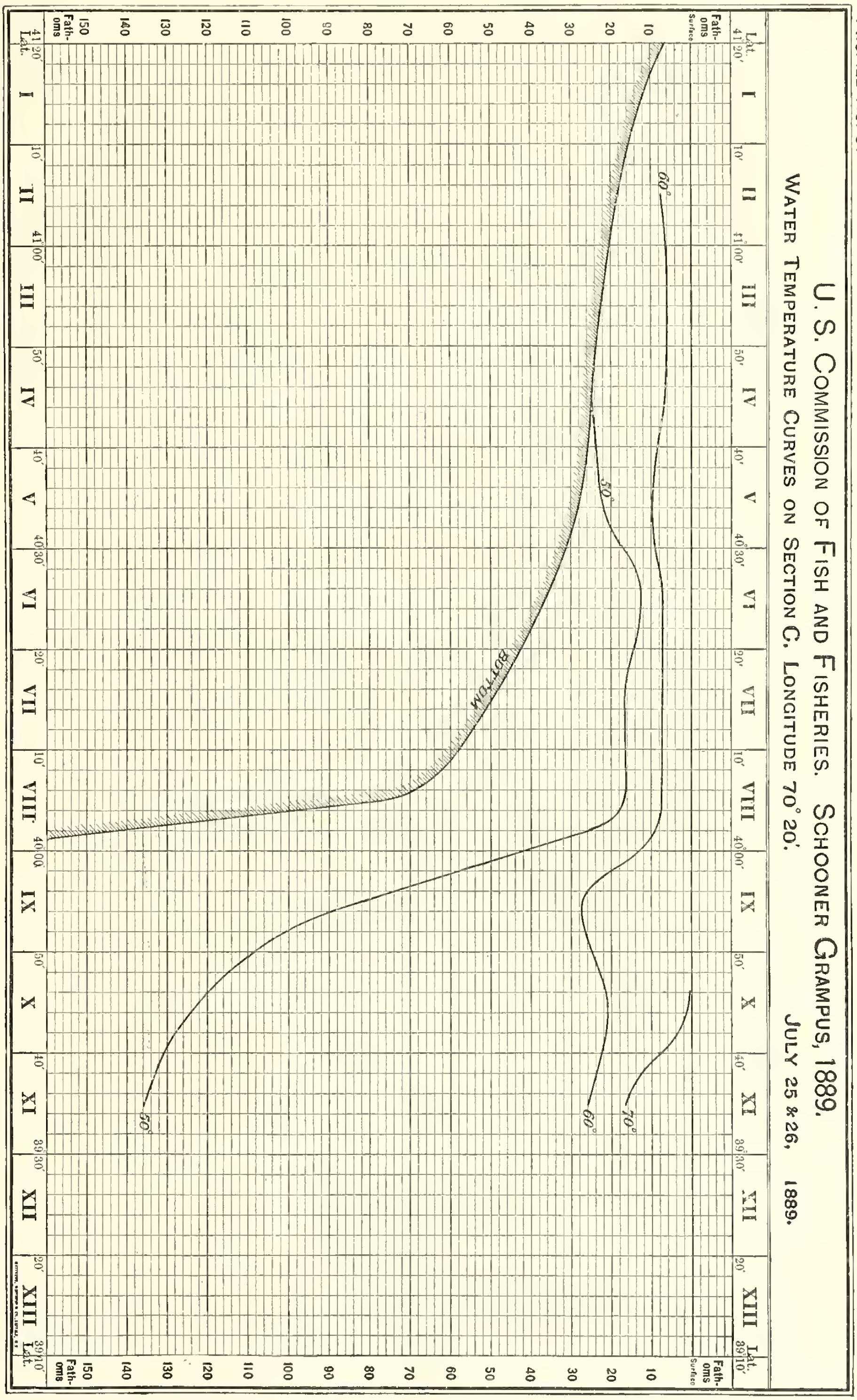
The Roman numerals at the top and bottom of the plate represent the corresponding spaces on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	STATIONS.												
	I. Depth 22 fath.	II. Depth 26 fath.	III. Depth 28 fath.	IV. Depth 32 fath.	V. Depth 34 fath.	VI. Depth 41 fath.	VII. Depth 54 fath.	VIII. Depth 150 fath.	IX. Depth 350 fath.	X.	XI.	XII.	XIII.
0	71.0	71.2	74.6	73.6	72.6	71.5	70.0	70.3	72.9	72.2	71.4	71.9	71.8
5	68.8	70.2	71.1	71.7	71.4	71.4	69.9	70.1	72.1	71.7	71.7	71.8	71.6
10	66.9	52.5	61.0	62.2	58.2	69.2	69.6	70.1	72.1	71.1	70.5	72.1	67.1
15	53.0	48.6	67.7	50.9	50.1	69.0	55.1	69.2	59.9	61.7	65.9	64.5	60.6
20	51.3	47.8	47.7	48.7	49.3	46.8	47.3	63.7	57.8	48.0	65.2	62.9	56.1
25	......	48.0	47.2	46.6	47.3	46.2	46.9	60.5	54.3	50.0	66.5	51.1	57.9
30	......	......	......	46.9	......	45.8	46.9	54.9	......	50.9	58.8	50.8	54.8
40	......	......	......	......	......	44.9	46.8	54.1	......	51.0	55.6	53.9	54.5
50	......	......	......	......	......	......	46.8	51.0	57.8	53.8	54.1	54.0	55.2
75	......	......	......	......	......	......	......	52.5	49.7	53.2	53.6	52.7	54.3
100	......	......	......	......	......	......	......	48.6	57.1	49.9	50.8	51.6	50.4
150	......	......	......	......	......	......	......	44.7	44.4	46.0	47.6	49.2	47.7
200	......	......	......	......	......	......	......	......	......	42.8	45.1	45.3	45.0
250	......	......	......	......	......	......	......	......	41.0	......	42.1	43.0	42.8
300	......	......	......	......	......	......	......	......	......	40.7	40.5	42.1	41.2
400	......	......	......	......	......	......	......	......	......	40.0	39.6	39.9	40.0
500	......	......	......	......	......	......	......	......	......	39.1	39.1	39.6	39.3
Bottom	51.3	48.0	47.2	46.9	46.3	44.9	46.8	44.7	39.5	......	......	......	......

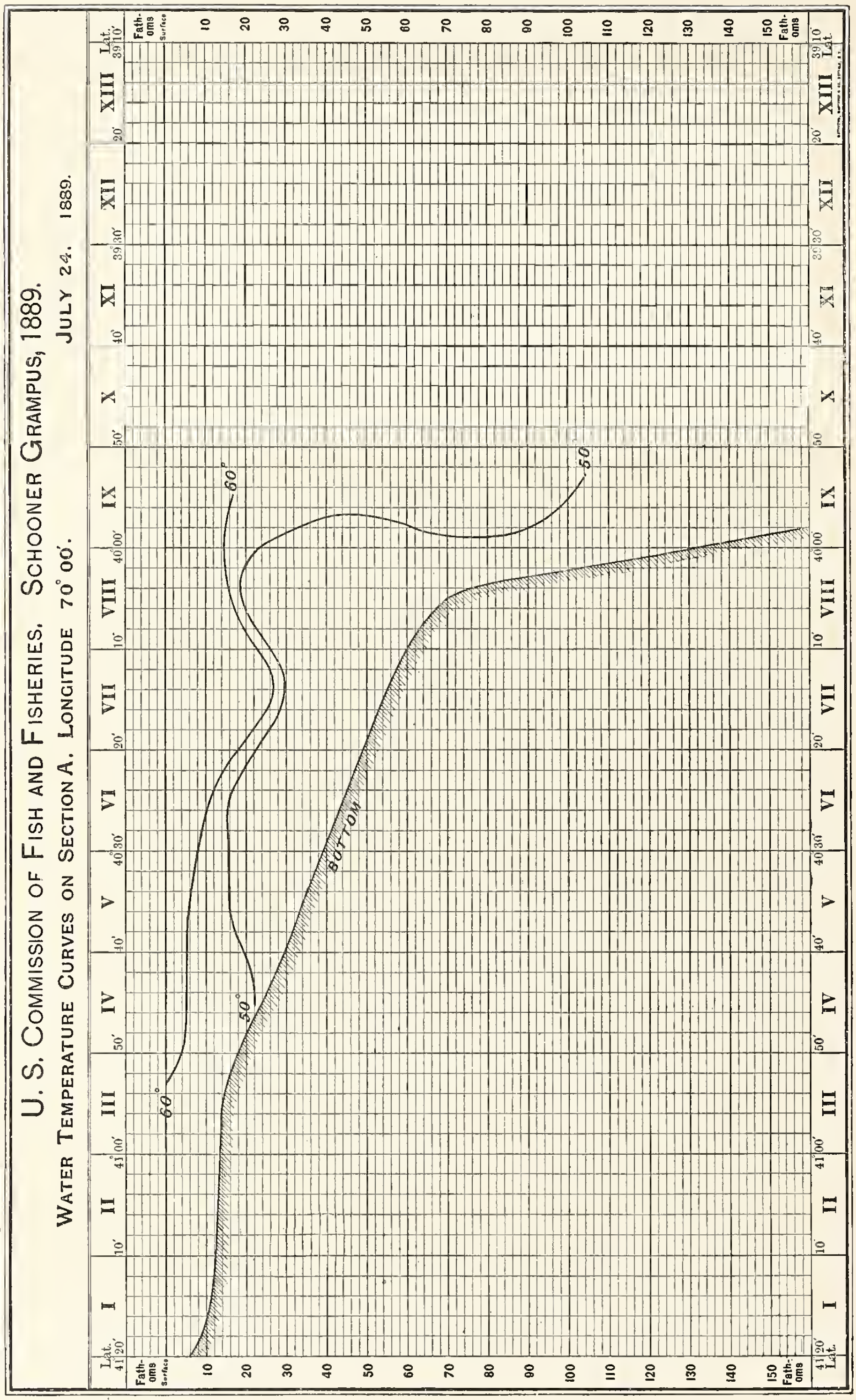
EXPLANATION OF PROFILE NO. 8.—WATER TEMPERATURE CURVES ON LINE C.

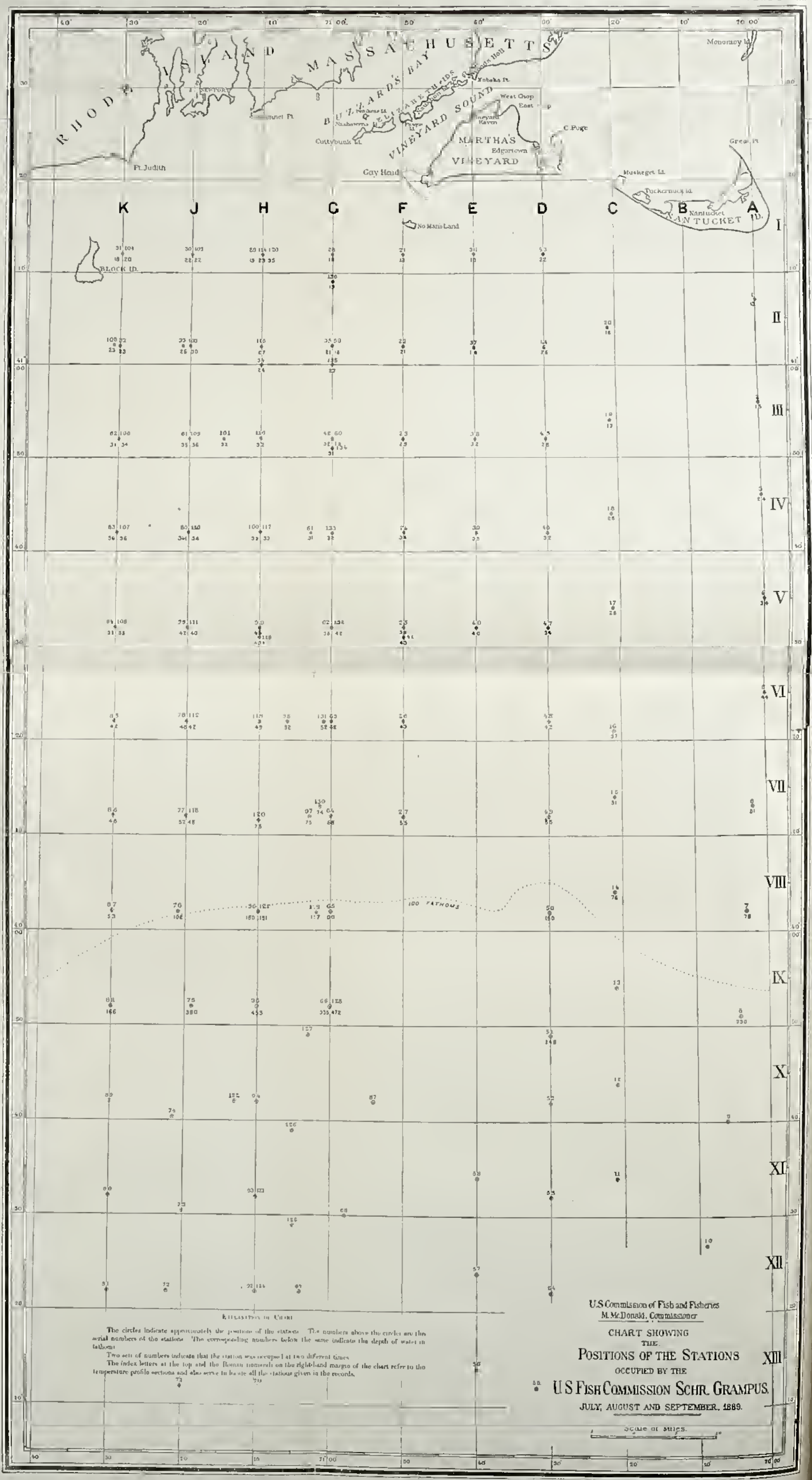
The Roman numerals at the top and bottom of the plate represent the corresponding spaces on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	STATIONS.												
	I.	II. Depth 15 fath.	III. Depth 20 fath.	IV. Depth 24 fath.	V. Depth 28 fath.	VI. Depth 34 fath.	VII. Depth 50 fath.	VIII. Depth 76 fath.	IX.	X.	XI.	XII.	XIII.
0		65.5	65.4	68.0	68.5	68.0	67.0	64.8	69.0	70.2	71.3		
5		63.9	62.3	67.8									
10		56.3	53.4	53.2	62.1	59.6	56.9	58.4					
15		63.3	52.1	50.5	55.0	49.0	51.1			64.9	71.4		
20					52.8		47.1	46.0					
25				50.6	54.5	49.0							
30							45.6	44.9		52.4	55.8		
40							45.2	45.9					
50							42.5	48.9	52.7	53.5	55.8		
75								45.3	50.3	54.0	53.4		
100									49.0	52.2	53.5		
150									45.7	47.2	48.5		
200									41.9	45.5	46.5		
250									41.1	41.5	45.5		
300									39.7	43.8	45.4		
400										39.7	39.7		
500													
Bottom		63.3		50.6	54.5	46.2	42.5	45.3					


PROFILE No. 8.
U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
WATER TEMPERATURE CURVES ON SECTION C. LONGITUDE 70° 20'.
JULY 25 & 26, 1889.
BOTTOM
60°
50°
70°
60°
50°
Fathoms
Surface
Lat.
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII

PROFILE No. 9.


U. S. COMMISSION OF FISH AND FISHERIES. SCHOONER GRAMPUS, 1889.
WATER TEMPERATURE CURVES ON SECTION A. LONGITUDE 70° 00'. JULY 24. 1889.
Lat. 41°20'
I
10'
II
41°00'
III
50'
IV
40'
V
40°30'
VI
20'
VII
10'
VIII
40°00'
IX
50'
X
40'
XI
39°30'
XII
20'
XIII
39°10' Lat.
Fathoms
Surface
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150 Fathoms
60°
50°
BOTTOM


RHODE ISLAND
MASSACHUSETTS
NEWPORT
BUZZARDS BAY
ELIZABETH IDS
VINEYARD SOUND
MARTHA'S VINEYARD
Edgartown
West Chop
East Chop
C. Poge
Gay Head
Cuttyhunk Id.
Nashawena Id.
No Mans Land
Pt. Judith
BLOCK ID.
Monomoy Id.
Great Pt.
Muskeget Id.
Tuckernuck Id.
NANTUCKET ID.
Nantucket
K J H G F E D C B A
I II III IV V VI VII VIII IX X XI XII XIII
100 FATHOMS
Explanation of Chart
The circles indicate approximately the positions of the stations. The numbers above the circles are the serial numbers of the stations. The corresponding numbers below the same indicate the depth of water in fathoms.
Two sets of numbers indicate that the station was occupied at two different times.
The index letters at the top and the Roman numerals on the right-hand margin of the chart refer to the temperature profile sections and also serve to locate all the stations given in the records.
U.S. Commission of Fish and Fisheries
M. McDonald, Commissioner
CHART SHOWING THE
POSITIONS OF THE STATIONS
OCCUPIED BY THE
U S FISH COMMISSION SCHR. GRAMPUS
JULY, AUGUST AND SEPTEMBER, 1889.
Scale of Miles.


70 00'

EXPLANATION OF PROFILE No. 9.—WATER TEMPERATURE CURVES ON LINE A.

The Roman numerals at the top and bottom of the plate represent the corresponding spaces on the general chart. The data upon which the curves are based are shown in the following table of temperature observations.

Depth (fathoms).	STATIONS.												
	I.	II. Depth 13 fath.	III. Depth 14 fath.	IV. Depth 24 fath.	V. Depth 34 fath.	VI. Depth 44 fath.	VII. Depth 54 fath.	VIII. Depth 70 fath.	IX. Depth 230 fath.	X.	XI.	XII.	XIII.
0		61.9	59.4	62.8	66.9	67.5	66.8	66.5	68.2				
5													
10						65.4	64.8	65.9					
15					50.9	51.8	66.7	66.1					
20						48.4	64.2	48.7					
25					46.7	46.0	64.5		55.8				
30						45.2	45.6	46.9					
40						45.7	45.6	45.7					
50							45.3	46.7	51.7				
75									53.6				
100									47.6				
150									42.9				
200									41.7				
250													
300													
400													
500													
Bottom		61.8	57.2	49.2	46.2	45.2	44.1	47.4					

22.—NOTES ON THE OYSTER FISHERY OF CONNECTICUT.

BY J. W. COLLINS.

(With Plates CLIX–CLXVI.)

I. INTRODUCTORY NOTE.

The following notes on the oyster fishery of Connecticut are based chiefly on the results of an inquiry made, under the direction of the writer, by Mr. Charles H. Stevenson, statistical agent of the U. S. Fish Commission.

The inquiry related particularly to the statistics, methods, and relations of the fishery during 1887, 1888, and 1889; but many additional data were secured, so that it has been practicable to place on record a tolerably full account of the leading events in the fishery since 1880, up to which date the subject was covered by Ingersoll's monograph of the oyster industry of the United States, prepared for the Tenth Census under the direction of the U. S. Commissioner of Fish and Fisheries.

In preparing these notes the object has been simply to call attention to the important commercial features of the industry; the scientific problems connected with this fishery will be considered by those who have studied them. The U. S. Fish Commission steamer *Fish Hawk* has been actively engaged for several summers in making a careful study of certain matters that affect the oyster fishery of Long Island Sound and adjacent regions.

The tabulated statements appended present in a concise manner the general commercial features of the fishery and contain also some special data not commonly shown in this manner, such as the summation of losses by starfish, etc.

No fishery on the Atlantic coast of the United States has attained greater success in recent years than the Connecticut oyster industry. Its history during the past decade has demonstrated the possibility (by well-directed effort, operating under wise laws) of the cultivation of areas of sea-bottom hitherto considered useless for commercial purposes. The success attained where the natural conditions are not specially favorable has attracted widespread attention, particularly in regions interested in the oyster fishery.

In many localities, especially in the Chesapeake Bay region, the general belief has been that the natural wealth of the oyster beds is inexhaustible. Trained from childhood to look upon the oyster grounds as their patrimony, and feeling that there should be no more restrictions upon catching oysters than upon taking any of the

free-swimming migratory species of fish that come with the seasons, it is, perhaps, not remarkable that the fishermen of the Chesapeake have bitterly, and to this time successfully, opposed all attempts at legislation intended to convey proprietary rights in the grounds. The following will illustrate the reliance upon nature:

The value of the oyster business alone to southeast Virginia is nearly $2,500,000 per annum. It is a crop constantly harvested except in the months of May to August inclusive, and is as constantly replenished by the bountiful hand of nature. No city in the Union is more highly favored in this respect than is this city of Norfolk. It is a crop that requires no sowing or planting, no cultivating—nothing but harvesting. Nature does everything except harvesting the crop.—From "Our Twin Cities of the 19th century (Norfolk and Portsmouth)," Norfolk, 1887-88, p. 91.

Fishing has gone on with little restriction and the depletion of oyster grounds has been so marked of late as to cause the gravest apprehension in both Maryland and Virginia. Thus, while a valuable oyster industry has been built up and maintained in Connecticut under comparatively adverse natural conditions, the most important oyster region of the world is rapidly losing its prestige, and, unless new methods or regulations are adopted, there is reason for apprehending the most unfavorable results in the near future. There can be no question that the example set by Connecticut has been a most useful and important one, and all communities interested in the oyster fishery will doubtless profit by it.

In view of the results of shellfish legislation in Connecticut and the many inquiries about the subject, abstracts of some laws and the full text of the recent and most important ones will be appended.

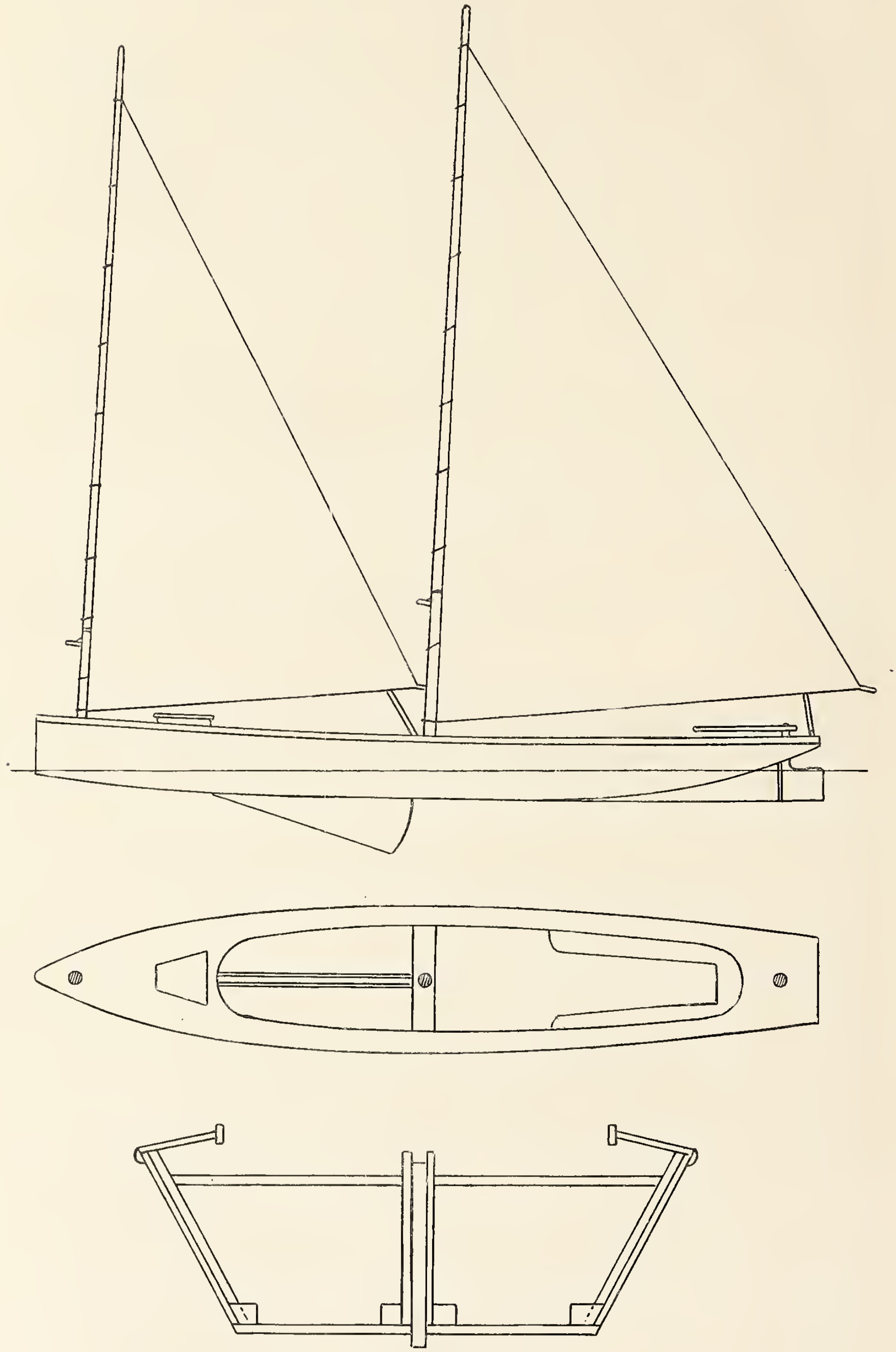
II.—PERSONNEL, WAGES, ETC.

1. *Number and nationality of persons employed.*—The total number of persons employed in the Connecticut oyster industry in 1889 as fishermen and shore operatives was 1,208, which did not differ materially from that of the two previous years. Of these 593 were employed on vessels and boats in cultivating the beds and harvesting the crop. Under ordinary conditions these would be classed as fishermen, but here they engage in sea-farming as well as fishing, and have been designated accordingly.

The shore operatives—those engaged in preparing and shipping the products—numbered 651, of whom 344 were women. The latter are employed mostly at New Haven as "openers;" about one-third of them are of foreign birth, principally natives of Ireland. The men are mostly American-born and natives of New England. The fishermen (or sea-planters) are noted for thrift, enterprise, and aggressive energy, important characteristics in developing the industry in which they are engaged.

In detail, 525 of those employed in cultivating and fishing are citizens of the United States, 24 are Swedes, 11 Germans, 21 Irish, 5 Portuguese, 1 Russian; the nationality of 6 could not be ascertained. Of the shore operatives 521 are Americans, 14 Swedes, 10 Germans, and 106 Irish.

2. *Wages.*—At New Haven the men employed on vessels receive from $10 to $15 per week and board themselves, but at Bridgeport and west of that place laborers are paid about $30 per month with board. The captains and engineers on the steamers receive much higher pay, frequently $80 per month with board. The board is reckoned at about $12 per man per month. The average annual wages of those engaged in oyster fishing and cultivation exceeds $300. In 1889 wages to the amount of



SAILING SHARPIE.

[From Report on the Ship-building Industry of the United States, Vol. VIII, Tenth Census.]

$213,995 were paid to 693 employés. Reference may be made here to the fact that the earnings of these men are increased considerably by the sale of oysters taken on the natural beds. Stevenson estimates their average annual earnings at about $385. This average is low because some of the men do not engage exclusively in the oyster industry, but devote a portion of their time to fishing, farming, or some other occupation. It is claimed that a man without capital can easily earn $500 per year if he is efficient and works all the time. This is much more than could be earned fifteen years ago and much in excess of wages generally received by oystermen elsewhere; for instance, on the Chesapeake. Some fishermen are small proprietors and derive an additional income from their grounds as well as by working on public beds.

Operatives on shore other than "openers" receive from $10 to $12 per week, without board. At New Haven openers are paid 3 and 3½ cents per quart of meats. In 1889 the 461 openers at that city were paid $70,106, an average for the season of about $175. About three-fourths of the oyster-openers are women, many of whom work somewhat irregularly a part of the year.

The following statements of prominent oystermen regarding the wages of shore operatives will be of interest. Messrs. S. & D. Chipman say:

> Oyster-shuckers earn from $5 to $7 a week. A few earn as high as $12 a week.—Report of Connecticut Bureau of Labor Statistics, p. 130.
>
> The openers at City Point receive 17½ cents for a 5-quart pail of opened oysters. The measure is beer, and includes the liquor. The cost of opening a gallon of solid oysters, wine measure, is 20 cents at the above rate to the openers, about 3 cents a gallon being allowed for help and expenses incidental to washing and packing. Oyster-openers average about $2 a day working 8 or 9 hours, but the amount of work varies from day to day. Indeed, the number of quarts opened depends much on the ability of the opener, varying from 40 to 120.—*Ib.*, p. 133.

The 86 men employed at New Haven market houses as "helpers" earn a yearly average of $275 for the season, November to May, and for work at odd times between seasons.

III.—VESSELS AND BOATS.

3. *Influence of improved vessels.*—Next to the enactment of favorable laws, nothing, perhaps, has exercised so much influence on the development of oyster farming in Connecticut as the recent improvement in the vessels engaged in this industry.

4. *Historical.*—In early times small rowboats were practically the only craft employed in oystering in this region. These were chiefly, if not wholly, dugout canoes, of which examples are still to be found along the Connecticut shores, though now seldom used. As late as 1880 Ingersoll found fifteen or twenty dugout canoes at New Haven and vicinity employed in taking seed and marketable oysters. The canoes were generally large, and would carry about 40 bushels of oysters. Stevenson says a few of them "may still be seen upon the banks of the Quinepiac, prized more as mementoes of the past than for their present usefulness." In many places the dugouts were superseded by a flat-bottomed, square-ended, scow-like skiff, worth about $10; but at New Haven and vicinity the sharpie came into general favor some years ago, and was more extensively used in oystering than any other type of boat.

5. *The sharpie.*—The fishermen of Connecticut are credited with originating this craft, which, during the era when boats were chiefly used in the oyster industry, was admirably adapted to the business. Having a sharp bow and a broad, flat bottom,

the sharpie is capable of carrying a large cargo on a very light draft, an important feature in an oyster boat, since it is thus able to pass safely over the scarcely submerged oyster beds. The sharpie is also a swift-sailing vessel under ordinary conditions. At New Haven it is still extensively used. The largest size is chiefly employed in oyster fishing and carries from about 150 to 200 bushels of oysters.

Boats more than 20 feet in length are generally fitted for sailing. They are built longer in proportion than the smaller sharpie, fitted with a centerboard, and, if more than 25 feet long, carry two large leg-of-mutton sails, the foot of each being held straight by a sprit in the clew, the other end of the sprit being fitted into a loop on the mast. Occasionally one of the largest may have booms on its sails. The masts are long and tapering, and usually very small in diameter in proportion to their length. In a stiff breeze they bend like the bamboo yard of an East Indian boat. As a rule the foremast is about six times the beam in length; the mainmast is generally, though not always, shorter, say about five and a half times the beam in length; the spars are seldom supported by shrouds, but a single small wire shroud may sometimes be put on each side of the masts of the very largest boats. The general belief is that the stiffening of the mast by stays and shrouds is detrimental to the sailing qualities of a sharpie.

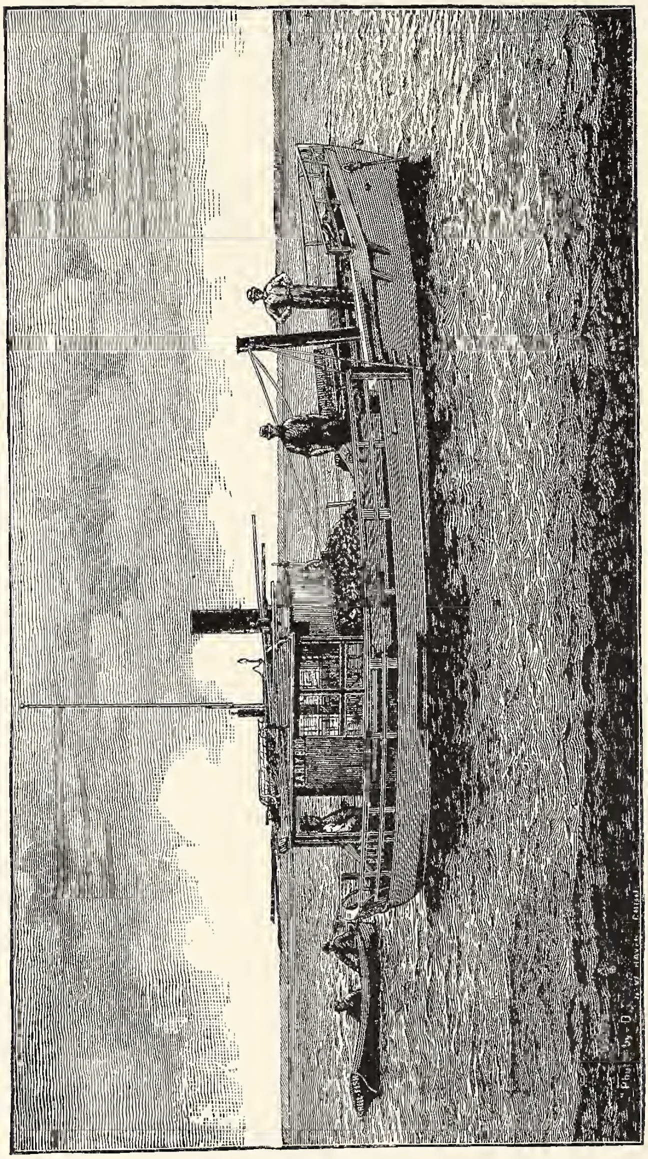
The larger sharpies are usually decked over for a short space at bow and stern, and have washboards running along the sides. The centerboard is a little forward of amidships. There is a good deal of camber to the bottom, particularly in the after section, where there is a deep skag. The lower part of the bow rises nearly to the surface of the water; the rudder is hung outside and is usually very wide. The accompanying illustrations show the form and rig of the typical oyster sharpie. In constructing a boat of this kind, oak and chestnut are used for frames, skag, and gunwales; the planking is pine. Ordinarily, there are two full strakes of planking on a side, and an additional strake at the ends to give the sheer. The planks on the bottom are always put on athwartships. The cost ranges from $200 to $400 for the largest class of sharpies, though those employed in the oyster fishery rarely exceed $200 in value, since many have been in use for a period of years. The following are the dimensions of one of the large oyster sharpies (see plate CLIX): Length, over all, 35 feet; extreme beam, 6 feet; width of floor amidships, 4 feet; depth, 2 feet; height of foremast, 35 feet 6 inches; mainmast, 33 feet 4 inches. Some of the sharpies are wider in proportion than the one figured, the dimensions of which are given above. It is not uncommon for a sharpie 36 feet long to be 8 feet wide and have a capacity for 200 bushels. The Fair Haven boats of 32 to 34 feet carry from 100 to 125 bushels.

6. *Sloop boats.*—In recent years a few full-bodied sloops, about 30 to 40 feet long, have been built in Massachusetts for this trade. These are very burdensome craft, and are also reputed to be fairly good sailers.

7. *Scows.*—A few scows are employed; these are the typical flat-bottomed, square-ended variety.

8. *Sailing vessels.*—Prior to the adoption of steam vessels for dredging, small sloops and schooners were used, and even now many sailing vessels are employed in the Connecticut oyster fishery, in one capacity or another, though the general tendency is toward the substitution of steam power for sail.

Boats and sailing vessels are most numerously employed in the western part of the State, as will be seen by reference to the statistics appended. From 1887 to 1889



THE FIRST OYSTER STEAMER, EARLY BIRD.

[From the Fifth Annual Report of the Connecticut Bureau of Labor Statistics.]

inclusive there was little variation in the number of boats engaged in the oyster industry. Thus, there were 551 boats in 1887, 550 in 1888, and 549 in 1889.* But while the number has decreased slightly there has been a steady improvement in quality and value. The value of boats and outfits amounted to $61,245 in 1887, $61,310 in 1888, and $61,574 in 1889.

The sailing vessels have declined slightly in both number and tonnage in the same period, as follows: 67 vessels of 752.70 tons in 1887, 63 vessels of 692.29 tons in 1888, 59 vessels of 631.01 tons in 1889. It will thus be seen that the average is only about 11 tons. Their value, including outfit, was $52,405 in 1887, $45,190 in 1888, and $40,930 in 1889.

9. *Work done by boats and sail craft.*—The skiffs, canoes, and sharpies are utilized chiefly for tonging and light dredging; the sailing vessels in spreading shells, etc., over the grounds and in dredging. The latter are mostly sloops, and operate two dredges each; they can not work in calm weather, but since they have exclusive rights on the public beds (where the use of steam is prohibited) they are in favor with small operators and will doubtless form a part of the oyster fleet of this State for some years to come.

10. *Introduction of steamers for oyster dredging.*—Screw steamers have recently been introduced and very successfully employed in the Connecticut oyster fishery. Steam is used for working the dredging apparatus as well as for propelling the vessel, and has effected a great saving of time and labor.

Capt. Peter Decker and his brother, of Norwalk, Connecticut, are credited with having first employed steam to work oyster dredges. They put a boiler and engine into the sloop *Early Bird* to turn the drums on which the dredge lines were hauled, the sails being still depended on to propel the vessel. Afterwards they made an additional improvement by attaching a small screw to their sloop, thus obtaining auxiliary steam power to assist in propelling the vessel when the wind was light. The result of these innovations demonstrated so fully the feasibility of using steam in the oyster trade that ultimately they put a larger boiler and more powerful engine into their vessel, and depended on steam altogether, the mast, bowsprit, and sails being removed (see Pl. CLX). Thus in a short time the sailing sloop was gradually converted into a dredging steamer, and the vessel's effectiveness much improved. By the new arrangement she could haul two dredges at once, taking up from 150 to 200 bushels of oysters per day.

The success of these experiments led others to adopt the same method. A correspondent writing to the Sea World, of August 4, 1879, says:

> After the experiments of Messrs. Decker Brothers, Mr. W. F. Lockwood, of Norwalk—not an oyster man but an enthusiastic believer in steam dredging—built the steamer *Enterprise* expressly for the business. Her length is 47 feet; beam, 14 feet; and she draws 4 feet of water. She handles two dredges, and hauls from 150 to 200 bushels daily. She cost about $3,000.

Replying to a letter of inquiry concerning the introduction of steamers in the oyster business, Capt. Peter Decker writes, under date of December 10, 1881:

> I put steam-power in my sloop for the purpose of towing and hauling my oyster dredges, in March, 1874, and found her capacity for catching oysters augmented about ten times without increasing her working expenses. In 1876, a boat for the same purpose was built at City Island, New York, and in 1877 another at Norwalk, Connecticut, making three, all told, and now I can count twelve in active

* Of the small boats employed in 1889 Stevenson reports 98 sharpies, of which number 82, valued at $12,955, are owned at New Haven.

operation and several in the process of construction. I have 56 acres of hard-bottom oyster ground which I was unable to use, owing to its being infested with starfish, and I could not keep them off until I put steam in my boat; then I cleared them all away, and in doing so, I cleaned the bottom to such an extent that it received the young oyster spat, and now the ground is covered with oysters and free from starfish. When I commenced to rig my sloop into a steamer, the rest of the oystermen laughed at me and said I was a fool; but after they found that I could catch more oysters than they could, they went to the legislature and had a law passed to prohibit steam dredging on natural oyster beds. But instead of destroying, I claim that the use of the steamers will create natural beds, which, I think, I have fully demonstrated by cultivating the 56 acres of ground mentioned above.

The *Early Bird* was 31.4 feet long, 13 feet beam, and 3.4 feet deep; she measured only 7.08 tons. After serving 17 years in the oyster industry she was accidentally burned in January, 1889.

11. *Increase in the steam oyster fleet.*—Immediately succeeding the introduction of steam in the oyster fisheries of Long Island Sound a considerable number of oyster steamers were built, and in 1880 there were six in the State of Connecticut, the largest measuring 29.71 tons net; in 1883 there were 31. The following table shows the increase since 1883:

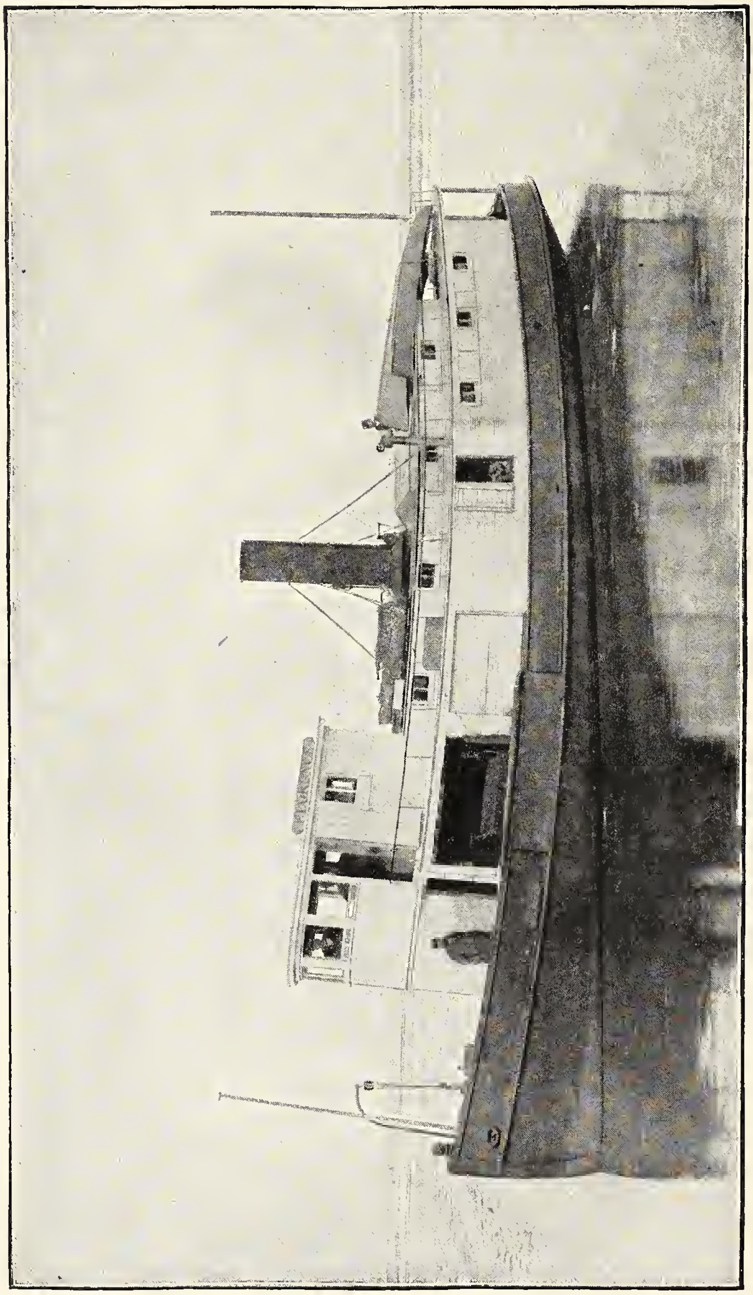
Year.	*No. of vessels.	Cargo capacity.	Aggregate tonnage.
		Bushels.	
1883	31	27,225	715.11
1884	40	36,720	1,004.80
1885	48	47,725	1,306.18
1886	53	53,325	1,498.23
1887	57	61,685	1,689.13
1888	58	63,770	1,759.26
1889	57	62,225	1,744.08

* Including three vessels under 5 tons each year.

12. *Size of steamers.*—These vessels were then, as now, small screw boats, resembling the steam tugs used for towing vessels. The steamers recently built, however, differ greatly from those in use in 1880. The largest was then less than 30 tons—the average about 15 tons. Now the average exceeds 30 tons, while the maximum size is 147.85 tons gross, or 73.93 tons net; several others are nearly as large. The dimensions, etc., of the largest steamer are: Length, 83 feet; beam, 20 feet; depth, 6 feet; cost, $16,000; carrying capacity, 2,500 bushels of oysters; fishing capacity, 1,800 bushels of oysters per day from grounds 35 feet under water; crew, 8 men for ordinary work; cost of fuel, water, and oil, about $100 per month.*

The average size of steamers built during the 5 years ending in 1889 is about 48 tons; length, 65 feet; beam, 18 feet; depth, 5.6 feet; capacity, 1,700 bushels; cost, $10,000; crew, 4 to 6 men.

*As illustrating the difference in capacity for work between sailing and steam vessels, it is conceded that the steamer above mentioned can dredge as many oysters in one day as can be taken by a medium-sized sailing vessel, with a crew of 3 men, in 70 days, working in the same depth of water, 35 feet. Considering the great difference in the working power of steam and sailing craft, it is not remarkable that the "natural-growthers" raised serious objection to the employment of the former on the public beds as soon as their capacity was demonstrated. The legislature compromised in 1879 by permitting steamers to dredge 2 days in each week throughout the year; but in 1880 dredging on public beds with steam was prohibited.



OYSTER STEAMER, FLORENCE.

[From the Fifth Annual Report of the Connecticut Bureau of Labor Statistics.]

13. *Details of form, etc.*—The steamers are wide and shallow. They have a sharp bow, moderately concave at load line; a straight, nearly vertical stem above water; rather low, flat floor; medium length of run, and round stern. They are generally built with a strong sheer, and provided with a large deck house for the accommodation of the engine room, pilot house, and also for the storage of oysters. Most of the steamers are housed in for almost their entire length, but those sailing from Norwalk and Five-Mile River have the deck open forward of the boiler, so that the wheelman can note the operations on deck and direct the vessel's course in accordance therewith; whereas, when the forward deck is covered, the steering must be directed by those on deck. The pilot regulates the speed, when dredging, by a small wheel lever, placed within easy reach, and properly geared for this purpose. There is considerable diversity in details of finish, etc. Some are more cheaply and roughly finished than others—"built strictly for business" and provided only with necessary fittings. Some are more elaborately equipped, having fine and handsomely furnished cabins, steam-heated pilot houses, and other accessories for comfort and convenience.

The steamer *William A. Lockwood*, one of the largest and finest of the fleet of 1880, is thus described by Captain Rowe, owner and master:

She has a length of 63 feet; a beam of 16 feet; depth of hold of 5 feet; draws 5½ feet of water aft and 2½ feet forward. The machinery is placed well aft and the oyster room amidships; the pilot house is on the hurricane deck. She has a double hoisting engine for hauling in the oysters, and also a very large engine for propelling the boat. Iron blocks and chains are used to haul the dredges. On either side of the boat are two doors provided with a roller, over which the dredge chains run smoothly. The propelling engine is 11 by 11 inches and the hoister 5 by 7 inches.

The following account of the same steamer gives more details of the arrangement and apparatus:

The most efficient and convenient oyster steamer in the country, and perhaps in the world, is that owned by H. C. Rowe, of Fair Haven, Connecticut. She is housed over to protect men and oysters from exposure to storm, sun, and cold, and can work in the coldest weather. She works four large dredges and when running full blast employs 10 men, and takes up 500 bushels a day in 35 feet of water. She is a new boat, having been run about a year. Her boiler is larger and her engine more powerful than usual in a boat of her size, and she can therefore be used for towing, and can force her way through heavy ice in the winter, so that her owner is sure of a supply of oysters for his customers when other dealers may be unable with sailing vessels to get them. Especially is this greatly valuable in connection with the European trade, her owner keeping informed by cable of the state of the market, and taking up and shipping large quantities when the market is high in Liverpool and London. Besides her regular propelling engine she has a double engine for hauling dredges, which hauls all four dredges full of oysters at once and lands them on deck, two on each side. She cost $6,500. To an oysterman like Mr. Rowe, who cultivates miles of ground and takes up 7,000 bushels in a month, such a boat is of immense convenience.—Sea World, August 4, 1879.

The foregoing is equally applicable to the oyster steamers of to-day, which are similar in form, equipment, etc., and differ chiefly in size.

Steamers have been extensively used only by the oyster-planters of Connecticut and New York; nevertheless, the success which has attended them may ultimately lead to their introduction in the Chesapeake Bay and elsewhere.

The number of steamers employed in 1889, of 5 tons and upwards, was 54, with an aggregate tonnage of 1,732.08.* These were valued at $287,100, and were equipped

* In addition to these there were three small steamers, each less than 5 tons, which have been included with boats in the tabulated statements.

with apparatus of capture worth $33,640, the combined value of vessels and outfit being $320,740. This, added to the value of sailing vessels above 5 tons and boats less than that, gives a total investment of $423,244 in the oyster fleet of Connecticut in the last year of which we have statistical returns.

IV.—HISTORICAL NOTES.

Much has been written concerning the early history of the Connecticut oyster industry; but, in order that its present condition may be better understood, a brief outline is given here of the most important changes that have served to place the industry under existing laws and regulations.

Prior to 1784 no restrictions were placed upon the oyster fishery, it being as free for the enjoyment of all as any of the open-sea fisheries of the present day. This soon led to the depletion of the beds, and it was ultimately evident to the State legislature that some restriction was necessary; but since each section desired legislation different from its neighbor, it was at first deemed best to empower each coast town to regulate the fishery to suit its needs. The result was the following enactment which we find among the "Acts and laws of the State of Connecticut in America for 1784:"

Be it enacted, &c., That any town in the State shall have the authority in town meeting to make rules and ordinances for regulating the fisheries of clams and oysters within their respective limits, or the waters and flats to them adjoining and belonging, and for the preservation of the same, and to impose such penalties as shall be thought proper by such towns for the breach of such rules and ordinances.

Under this law, many of the 24 towns along the coast enacted regulations which served chiefly to restrict the fishery in order to prevent the destruction of the industry. These regulations differed in many particulars, but the "2-bushel law," "close-time law," and a regulation requiring an oysterman to be a resident of the town he fished from, were common to most of the local enactments.

This policy continued in force nearly a century, being qualified from time to time by State regulations, the most important of which was enacted in 1845. This permitted a citizen of the State, under certain restrictions and regulations, to plant in domestic waters such oysters as were brought from other States. In the following year this privilege was extended to cover oysters brought from any place within the limits of the State of Connecticut. This action was caused by the increasing importance of the trade in Southern oysters and the frequent desirability of bedding for a time such as did not find a ready market as well as those taken from the public beds of the State. This did not affect operations on the natural beds, which continued to be depleted. As a result, the oysters obtained on them decreased in size until they became too small to be placed upon the market as taken from the beds; and it was necessary that they should be planted for a year or more that they might reach a marketable size. On this account, in 1855, the State legislature enacted what is known as the "2-acre law," granting each town the right to designate through a committee 2 acres or less of ground in its respective territory on which there was no natural growth of shellfish to any citizen for his use in the cultivation of oysters or other mollusks. This was followed from time to time by additional laws providing for the taxation, protection, sale, etc., of these private grounds. Two acres of oyster beds were then considered sufficient to satisfy the most ambitious. The designated ground may be

used for the cultivation of any kind of useful shellfish, yet oysters alone have so far received special attention. These privileges were not obtained without bitter opposition on the part of the "natural-growthers," as those persons are called who obtain oysters from the natural oyster grounds.

From this planting of small oysters it was learned a "set"* could be obtained on shells or on oysters placed on grounds other than natural beds. This knowledge led to an extension of deep-water planting, and was the source of the present prosperity of the oyster fishery of Connecticut.

Planting was at first confined entirely to shallow water, and it was not until about 10 years later (1865 and subsequently) that men were bold enough to put out oysters in as much as 20 feet of water. This was first done off Noroton Point, in the town of Norwalk. Steam-power was soon after (1874) introduced for dredging oysters both on public and private beds, and by means of this agency the depth was gradually increased on private grounds at Norwalk to 30 feet and more, and this was soon followed by deep-water planting in the vicinity of New Haven, and later in other parts of the State.

But experience soon showed that, to engage in the cultivation of oysters in deep water, much additional and costly apparatus was required, and it was not profitable to farm so small an area as 2 acres. Consequently, the "2-acre" law was evaded, and many additional acres were obtained by some oystermen, who induced their neighbors and friends to aid them by each making application for 2 acres, at the same time signing a quitclaim in favor of the person for whom the action was really taken. Large areas were obtained in this manner by some individuals; indeed, there is on record a deed or quitclaim transferring to one man the ground rights of 224 men. Much of the ground, however, was held solely by "squatter" rights.

The manner in which the ground was at that time designated was so loose and unmethodical as to cause much litigation. There were numerous conflicting claims among the owners of private grounds and between them and the "natural-growthers." These difficulties led to important legislation. In 1881 the State legislature recognized the necessity of placing the designation of the oyster grounds under systematic and authoritative control; therefore it enacted a law establishing the State Shellfish Commission, and invested it with the right of granting perpetual franchises "in such undesignated grounds within said area as are not and for ten years have not been natural clam or oyster beds."

The "said area" alluded to was "bounded westerly and southerly by the State of New York, easterly by the State of Rhode Island, and northerly by a line following the coast of the State at high water, which shall cross all its bays, rivers, creeks, and inlets at such places nearest Long Island Sound as are within and between points on the opposite shores from one of which objects and what is done on the opposite shore can be discerned with the naked eye, or could be discerned but for intervening

* There is no word in the Northern States for infant oysters, except the terms "set," "spat," "spawn," etc., all of which belong originally to the eggs or spawn of the oyster, and not to the young, but are frequently and confusedly applied as well to the half-grown mollusks. In the South the name "blister" (referring to its smooth, puffed-up appearance) is given to the infant oysters, and serves to distinguish them from "seed," "cullens," and "oysters," which represent the successively larger sizes and stages of growth.—The Oyster Industry of the United States, by Ernest Ingersoll, p. 95.

islands."* The oyster grounds not embraced within the area designated by this act were within the jurisdiction of the municipal authorities, and under the same law and regulations as before; a large part, however, had previously been assigned for private use.

By this enactment the oyster areas were divided into two classes; that under the Shellfish Commission, known as the "State grounds;" and the "town grounds," which were unaffected by the new law. But the area of the latter is so small (6,874 acres, or one-tenth of the total amount) that this discussion will be substantially limited to a consideration of the State grounds.

In the language of the Shellfish Commissioners:

> By its liberal provisions all old titles are confirmed and future titles are to be made certain by approved legal forms; while all who wish to embark in the business of oyster culture can secure grounds at the merely nominal price of $1.10 per acre; grounds, too, that will not fail to yield to well-directed effort and insure an abundant pecuniary return.

Other enactments followed, until at present the title to and confidence in the tenure of oyster franchises are as well assured as the titles to the lands above water; and so favorable to the promotion of the oyster industry has been this and the subsequent legislation that, in the trip of investigation from one end of the State to the other made by Mr. Stevenson, nothing in the line of legal patronage or protection was found wanting.

During the first month in which the commission was organized applications were received for 31,263.5 acres, or about one-tenth of the total area under its control; but of the amount thus applied for only about one-third was designated, due to conflicting applications and failure on the part of applicants to comply with the necessary requirements.

The establishment of the commission resulted in securing satisfactory relations between the officials and those engaged in the oyster industry. The result has been exceedingly gratifying, and it is a matter of State pride that, starting with conditions less favorable than in some other localities, an important business enterprise has been built up, and the fact has been clearly and forcibly demonstrated that the prosperity of a great commonwealth may be materially advanced by the proper utilization of areas of sea-bottom within its jurisdiction.

The organization of the Shellfish Commission, and the assurance that a proper legal title could be secured for grounds, induced the oyster-planters to enter into the business with energy and determination. The growth of the industry was marvelous. Large areas of ground were purchased. Larger steamers and improved apparatus of capture were rapidly constructed and put to work to cultivate what was previously a barren and unprofitable waste of sea-covered territory.

While the greater part of the ground was taken by those who intended to improve and utilize it, some was secured by persons who invested merely for speculative purposes, or who aided by furnishing capital to prosecute the business. Indeed, considering the small cost of the ground and the promise of quick and profitable returns, it is not strange that capital was attracted to this industry.

* Extract from law of 1881; see laws appended.

V.—THE OYSTER GROUNDS.

14. *Location and extent.*—The oyster grounds of Connecticut were formerly situated almost wholly in the shallow waters of the bays, coves, and estuaries along the coast, but about 1865, when the practicability of deep-water planting became apparent, areas farther from shore were utilized. This extension of cultivated bottom toward the middle of the sound has continued until now some of the beds are 8 miles from the mainland, reaching fully to the State line which divides Long Island Sound almost equally between Connecticut and New York.

This division gives to Connecticut about 370,000 acres, or nearly 580 square miles of Long Island Sound and adjacent bays. Of this area, some 35,000 acres lie within the bays and estuaries bounded and included by the "commissioners' shore line," and consequently subject to the jurisdiction of some one of the twenty-four towns within whose borders they lie; hence, they are known as "town grounds." The remaining 335,000 acres are "State grounds," under the control of the Shellfish Commission. About 15,000 acres of this region are covered with ledges and islands, so that some 320,000 acres are under water. Of the above, 5,819 acres are "natural oyster beds," thus leaving over 314,000 acres, of which the title to 70,132.9 is vested in individuals, and the remainder is still available for designation by the Shellfish Commission to whomsoever may desire to purchase any of it.

Of the 35,000 acres of "town grounds," 6,874 acres are owned by individuals, 13,482 acres are public beds, and the remainder, of but little value, lies at waste, and may be designated to individuals by the towns. The area held by individuals or firms varies from 2 to about 7,000 acres; the average is 186.5.

The number of proprietors of "State grounds," in each year since 1881, is as follows:

1882	216	1886	434
1883	290	1887	431
1884	385	1888	401
1885	423	1889	376

Stevenson says that, of the 376 proprietors of "State grounds," 16 own 28,443 acres, valued at $678,000, and cultivate 15,716 acres, upon which it was estimated there were 1,645,000 bushels of oysters.

In 1889 49 persons or firms had 10 acres or less; 40 held between 10 and 25 acres; 118 between 25 and 100, and the rest had upwards of 100 acres. The number of owners of "town grounds" in 1889, who had no "State grounds," was probably about 100 (none of whom own large areas), thus making an aggregate of some 476 proprietors of oyster grounds in the State. Some of these are not cultivators, but hold the property for speculative purposes.

The following table shows concisely and clearly the distribution of all the private grounds in the State:

Locality.	Under State jurisdiction.			Under town jurisdiction.			Grand total.
	Cultivated.	Unculti-vated.	Total.	Cultivated.	Unculti-vated.	Total.	
	Acres.	*Acres.*		*Acres.*	*Acres.*		
Greenwich	2,052.1	2,385.5	4,437.6	480	205	685	5,122.6
Stamford	694	882.6	1,576.6	125	65	190	1,766.6
Noroton	719.4	516.7	1,236.1	45	60	105	1,341.1
Norwalk	2,742	2,374.3	5,116.3	940	202	1,142	6,258.3
Westport	2,918.4	5,186.7	8,105.1	20	.....	20	8,125.1
Fairfield	991.8	1,747.2	2,739	.....	45	45	2,784
Bridgeport	1,055	3,144.6	4,199.6	59	4	63	4,262.6
Stratford	3,918.8	3,204.6	7,123.4	20	83	103	7,226.4
Milford	2,274.7	8,818.5	11,093.2	.....	.....	.....	11,090.2
New Haven*	6,949.8	7,014.2	13,964	1,812	454.7	2,266.7	16,233.7
Branford	200	1,098.6	1,298.6	120	730	850	2,148.6
Guilford	500	4,318.4	4,818.4	.....	810	810	5,648.4
Madison	580	3,632.5	4,212.5	18	282	300	4,512.5
Clinton	.....	168	168	35	.....	35	203
Saybrook	.....	25	25	.....	.....	.....	25
Thames River	.....	.....	.....	70	.....	70	70
Groton	.....	.....	.....	170	.....	170	170
Stonington	.....	19.5	19.5	20	.....	20	39.5
Total	25,596	44,536.9	70,132.9	3,934	2,940.7	6,874.7	77,007.6

* Including Orange and East Haven.

15. *Depth of water.*—The greatest depth of water in Long Island Sound is a few miles north of Great Gull Island, where it is 312 feet; the greatest in Connecticut limits is 190 feet, off the town of Norwalk. The depth of water over planted ground varies from 3 to 85 feet, the latter off the town of Norwalk; the average depth for planted grounds is from 30 to 35 feet.

16. *Designation of oyster grounds.*—Of the 70,132.9 acres of "designated State ground," 33,987.9* acres were granted prior to June 1, 1881, when the Shellfish Commission was established. The following table shows the area of State ground owned by individuals each year since June 1, 1881, and the acreage on which there were oysters in each of the years since records have been kept:

Period.	With oysters.	Without oysters.	Total.
	Acres.	*Acres.*	*Acres.*
1881*	.....	.....	33,987.90
1881†	.....	.....	51,444.10
1882†	9,007.00	48,818.60	57,825.60
1883†	‡11,500.00	61,036.80	72,536.80
1884†	14,066.00	64,976.48	79,042.48
1885†	16,201.70	63,454.00	79,655.70
1886†	20,714.20	63,823.60	84,537.80
1887†	17,800.00	60,649.30	78,449.30
1888†	17,400.00	57,067.56	74,467.56
1889†	15,400.00	54,732.90	70,132.90

* June 1. † December 1. ‡ Estimated.

It will be observed that the area held by individuals steadily increased until 1886, since which time it has constantly decreased. This is due to the following reasons: When the commission was established in 1881, and even before, the value of the oyster grounds was beginning to be appreciated, and as soon as it was made evident

* These figures, as well as many of the following relative to oyster grounds, were taken from the records in the office of the State Shellfish Commission; hence they are as correct as can be obtained.

that their titles would be secure cultivators obtained as much as practicable of what was thought to be "good ground;" but, because of a limited knowledge of the needs of the oyster and of the character of the bottom, many acres of unsuitable ground were secured. Much of this was resold to the State in consideration of $1 per acre, under the provision made in one section of the act establishing a Shellfish Commission, providing for the return to the State, under certain restrictions, of all ground found, after a fair trial, to be unadapted to the cultivation of oysters.

The decrease in area designated annually is due to several causes: The grounds held by the State have unavoidably become more and more distant from the fishing centers and markets; the condition of the distant ground is generally less desirable than the designated areas; the chance of obtaining a "set" is uncertain, and the danger from the starfish is great; it has therefore generally been deemed unwise to attempt the improvement of remote areas under such disadvantages. It is believed by some that there are yet many acres of unappropriated bottom equally as good as much which has been taken up.

17. *Value of oyster grounds.*—The present market value of all the private ground in the State is about $1,237,695, of which $920,820 is for the cultivated grounds, and $136,875 for the unimproved portion. This gives an average value for the former of $31.14 per acre, and for the latter of $6.46 per acre.

The value of cultivated grounds varies from $5 to $2,500 per acre, the latter being the price for a few acres in New Haven Harbor, where southern oysters are bedded in spring to be taken up in the fall. The price paid for this was $1,300 per acre. The best grounds lie off New Haven, Norwalk, Stratford, and Bridgeport; those in the eastern part of the State are less valuable.

But values are constantly changing, since localities that are very productive one year may be almost worthless the next, on account of being covered with sand, mud, etc. The best ground has a clean, rocky, or shell bottom, in a moderate current of deep and brackish water, and in the neighborhood of other beds of spawning oysters. A muddy bottom causes the oysters to grow fast, but they are liable to suffocation, and besides have not so delicate a flavor as those raised on rocky ground. Much of the muddy ground has been recently reclaimed by spreading upon it large quantities of sand and gravel, but this is a somewhat costly method. Sometimes a bed may be slightly lower than the adjacent grounds, thus causing it to receive many oysters from adjoining areas, increasing the value of the one at the expense of the others.

While there may be considerable fluctuation in the value of bottom devoted to oyster culture, it will be observed that the average is much above that of land used for strictly agricultural purposes, while the annual product of the 15,400 acres on which there are oysters amounts to about $1,500,000, and this on an area which, 15 or 20 years ago, was for the most part unproductive.

18. *Taxes.*—The State derives a small revenue by a 1 per cent. tax on about a 50 per cent. valuation on the grounds under the jurisdiction of the Shellfish Commission, while some of the towns collect a uniform tax of 25 cents per acre from the areas within their jurisdiction. The State grounds thus cost the holders at first $1.10 per acre, plus expense of buoying, etc., and an annual tax averaging about 8¾ cents per acre. The minimum tax collected from a single individual in 1888 was 25 cents; the maximum tax on a private holding was $666.33; the total tax amounted to $6,761.83.

19. *Public beds.*—The following statement occurs in a decision made by an able judge in the State of Maryland:

Land can not be said to be a natural oyster bar or bed merely because oysters are scattered here and there upon it, and because, if planted, they will readily live and thrive there; but wherever the natural growth is so thick and abundant that the public resort to it for a livelihood, it is a natural bar or bed.

Perhaps no better definition, legal or otherwise, of what constitutes a natural oyster bed has been given; yet the history of the public grounds of Connecticut illustrates the fact that this definition is scarcely complete, because it takes no cognizance of the variation in productiveness of oyster beds in short periods of time. A bed may produce abundantly one season, and so little the following year that only few persons will resort to it. An excellent example of this is the famous Bridgeport bed, from which were taken 115,000 bushels of oysters in 1887, while in 1889 only a very small portion of it was fished on, and the yield was not more than 3,500 bushels. This has been almost equaled by the beds of New Haven Harbor (not including Quinepiac River), which produced in 1888 about 65,000 bushels of oyster seed, and in 1887 and 1889 only about 5,000 bushels in each year. It will thus be seen that the foregoing definition is scarcely correct, for what is a natural bed one year may not be such the next year; and in order that no cause for grievance may lie with the "natural-growthers," no ground in Connecticut can be designated that has at any time for 10 years previous been a natural bed in the sense of the above-mentioned decision.

20. *Area and products of natural beds.*—The following statement shows the area of natural beds in each town under the town and State jurisdiction, and also the quantity and value of the product for the years 1887, 1888, and 1889:

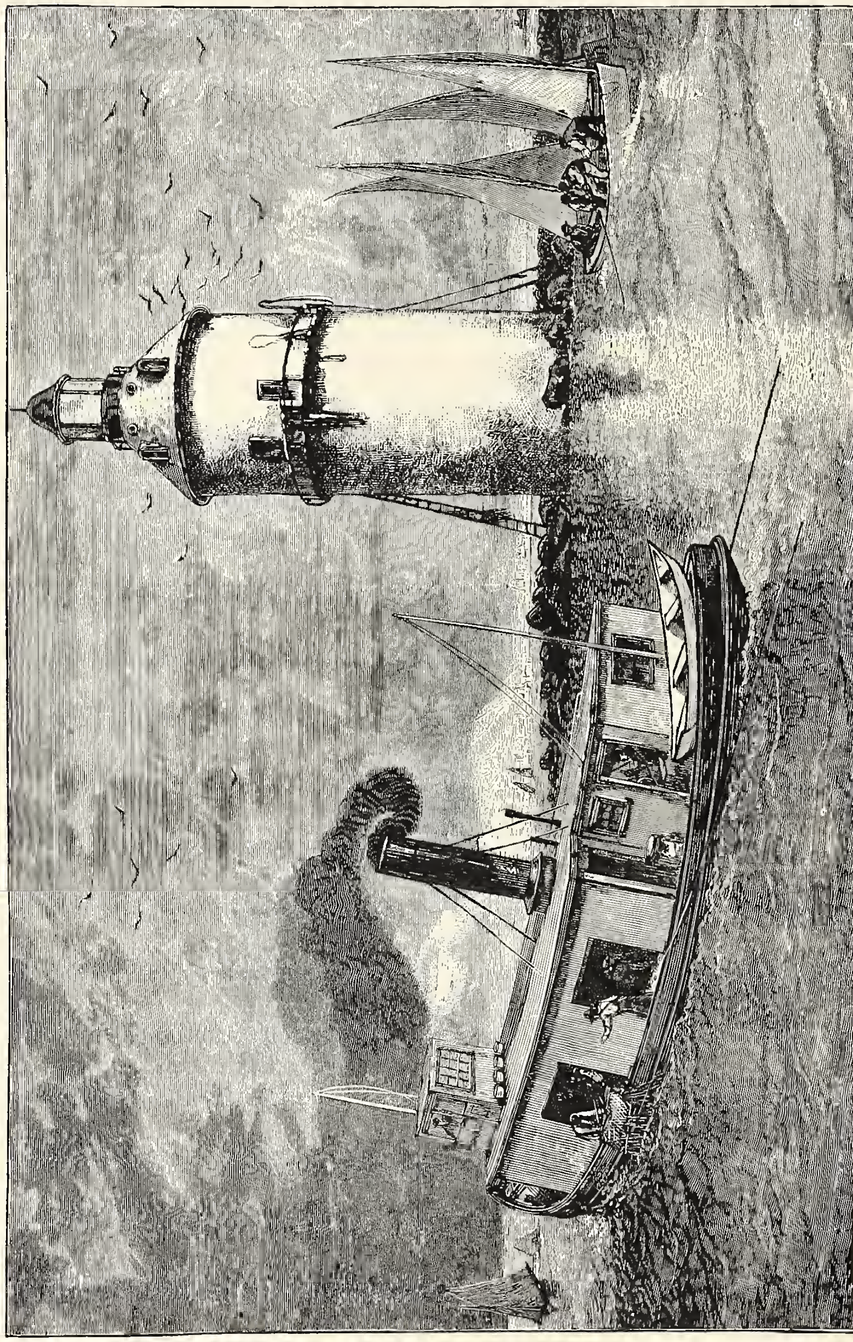
Locality.	Town.	State.	Total.	Yield 1887.		Yield 1888.		Yield 1889.	
	Acres.	*Acres.*	*Acres.*	*Bushels.*	*Dollars.*	*Bushels.*	*Dollars.*	*Bushels.*	*Dollars.*
Greenwich	1,600	875	2,475	6,200	2,170	6,000	2,350	1,200	360
Stamford	350	....	350	2,400	800	2,000	700	1,500	500
Noroton	275	150	425	2,000	800	1,900	800	1,100	520
Norwalk	1,650	160	1,810	28,000	8,400	21,500	6,260	12,500	5,750
Westport	1,400	90	1,490	3,000	800	3,000	800	2,500	800
Fairfield	800	1,150	1,950	4,000	1,200	4,000	1,200	3,500	1,200
Bridgeport	1,240	334	1,574	115,000	19,800	31,000	12,610	3,500	1,700
Stratford	1,442	3,050	4,492	19,000	3,800	8,000	2,500	4,500	2,200
Milford	1,000	....	1,000	6,000	2,150	10,000	3,400	8,000	2,400
New Haven	2,900	....	2,900	35,000	12,500	81,000	18,000	24,000	9,875
Branford	125	....	125	850	285	900	270	1,100	330
Madison*	200	....	200	12,500	4,500	7,000	2,850	5,500	2,580
Clinton	250	....	250	3,500	1,800	3,500	1,800	3,500	1,800
Westbrook	50	....	50	1,800	1,300	1,300	1,000	1,000	650
Saybrook	150	....	150	750	950	1,500	1,900	200	275
Niantic	5	....	5	....	....	....	....	40	80
Thames River	20	....	20	2,000	1,000	1,850	925	120	60
Groton	25	....	25	800	2,000	460	1,150	90	225
Total	13,482	5,809	19,911	242,800	64,255	184,910	58,515	73,850	31,305

* Including East River, a part of which is in the limits of Guilford township.

21. *Restrictions about fishing on public beds, etc.*—No one is permitted to use steam in any manner for taking oysters from the public beds, and no dredge or other contrivance weighing over 30 pounds may be employed.

Ten years ago more persons were at work on the natural beds than on private holdings; but, although the attention paid to private grounds has diminished the number of persons depending on natural areas, the natural beds have become so de-

PLATE CLXII.



OYSTER-DREDGING STEAMER AND SHARPIES AT WORK IN LONG ISLAND SOUND.

pleted that at present no one depends wholly on them. The value of oysters from natural beds amounted in 1889 to only $31,305, while the yield of the cultivated beds brought $1,040,372, or more than 33 times as much. Of the 73,850 bushels obtained from public beds in 1889, about 5,000 bushels were marketed for food; the remainder were used for seed by the cultivators of this and other States.

22. *Effect of the State policy.*—It will be observed from the foregoing that, had Connecticut pursued the present policy of Maryland and Virginia, her oyster fishery in 1889 would have supported about 60 men. Under the present system over 1,200 persons, exclusive of capitalists, are directly dependent on the oyster industry, while many more are supported by constructing steamers and dredges, making tubs, baskets, etc., expressing oysters, and by the many other industries more or less dependent upon the prosperity of the oyster fishery.

VI.—METHODS OF CULTIVATION, TRADE, FISHING, ETC.

23. *Obtaining ground.*—Whoever desires to cultivate oysters in Connecticut must first obtain possession of a section of suitable ground. He may either buy this from some one in the business or secure it from the State Shellfish Commission at $1.10 per acre. By the former method he will either be likely to obtain poor ground or to pay many times as much as an equal area purchased from the commission would cost. Shrewd operators bear in mind that although the choicest grounds are in the hands of individuals, yet there are many acres of worthless private holdings, while the State still has much worth cultivating.

The best course is to serve an apprenticeship until one becomes sufficiently acquainted with the business to wisely select his own ground. Next best to this would be to employ an experienced and reliable cultivator to secure it. The ground should be as much together as possible for general convenience and to keep it free from starfish.

24. *Preparing the ground for a "set."*—After the ground has been obtained and the proper boundaries located, it is best to go over it with a steamer and dredge from it all extraneous substances generally classified as "rubbish." Those most extensively engaged in the business have steamers, some firms own several, while a few parties have no apparatus, their work being done for a certain sum by those who own steamers or sailboats. One or two dredging steamers belonging in the State are kept for daily hire; their owners have no oyster grounds and seek employment from those who have. These steamers, with the crews, may be hired for from $20 to $30 per day.*

If the ground is somewhat muddy some cultivators place gravel upon it at the rate of 100 to 200 tons to the acre. This system has produced excellent results.

The first plants of oysters may be made upon a new bed in three ways:

(1) Young "seed" oysters taken from the natural beds may be distributed over the ground, together with gravel, "jingles," or other shells taken therewith.

(2) If the area is distant from the spawning grounds it is often best to scatter adult oysters upon it, some time prior to July, the beginning of the spawning season, in order to secure a "set." In such cases, about 25 to 50 bushels of oysters are spread over each acre. Oysters are not usually purchased for this purpose. If a cultivator

* In the report of the Connecticut Bureau of Labor statistics for 1889 (p. 114) the statement is made that "nine steamers oyster in the sound, but are owned in New York."

has any beds remote from those containing spawners, and for this reason it is necessary to plant with adults, he generally has other grounds from which the requisite supplies can be obtained.

(3) If a new bed is near cultivated areas amply supplied with spawners it is only necessary to prepare the ground for a "set." Indeed the system of planting adults is less extensively practiced than it was a few years ago. In 1887 the amount of spawners transplanted in the State was 73,800 bushels, of which one firm handled over one-half; in 1888, 69,525 bushels were utilized in this manner, and in 1889 only 64,200 bushels.

In all cases, whether spawners are planted or not, the careful cultivator will, during July, spread about 300 bushels of shells as evenly as practicable over each acre of his ground. Sometimes they are distributed much more abundantly, but this quantity is sufficient if the shells are spread evenly and the bottom is not too muddy.

July is a busy month for those engaged in oyster cultivation. Some firms employ as many as 50 or 60 men, besides numerous schooners, scows, or other craft to distribute shells and prepare the beds to receive the spat. To obtain a good "set" means prosperity, while the lack of it causes scarcity and renders the business less profitable.

Some idea of the extent to which shells are employed in preparing oyster grounds in Connecticut may be obtained from the fact that at New Haven alone 1,298,580 bushels were planted in 1887, 1,269,300 bushels in 1888, and 1,148,125 bushels in 1889. A single firm has made annual deposits of 425,000 bushels.

East of Norwalk the cultivators use oyster shells obtained chiefly from the opening houses in New Haven and vicinity. The shells cost about 5 cents per bushel, and to distribute them costs from 2 to 3 cents per bushel. A large quantity is also obtained from the Housatonic River. At Norwalk and further west, several varieties of shells are used in addition to oyster shells. These are chiefly "jingles" (*Anomia ephippium*), "quarter-decks" (*Crepidula fornicata*), and "scallops" (*Pecten irradians*), obtained mostly from Peconic Bay, at the eastern end of Long Island, where about 325,000 bushels of mixed shells are annually taken and carried to the oyster regions of Connecticut and New York. The use of "jingles" and "quarter-decks" for this purpose originated in 1880, when Capt. James Monsell, of Greenport, Long Island, began the business, which he controls at the present time.

25. *Comparative merits of gravel, various kinds of shells, etc.*—It is probable that gravel is as desirable a material for the "clutch"* as anything yet used in Long Island Sound. Its comparative value is not dependent entirely upon its cheapness. It is considered by many preferable to oyster shells, because only one or two young oysters would "set" upon each pebble, and there is not the crowding that often occurs when large shells are used, since it is easy to distribute the spat attached to gravel whenever proper to do so. Oysters not crowded are more uniform in shape and better generally than those piled upon each other in clusters. For this reason the small "quarter-decks" and fragile "jingles" are considered much better than oyster shells. Some planters hold that they have a special value, because they are easily broken by the action of the water and thus do not encumber the ground after serving their purpose as "spat-gatherers." This is one reason why the shells from the Housatonic River are so much desired. It seems somewhat remarkable that oyster shells are not

* This term, imported from Europe, has been changed from "cutch" or "cultch," to clutch. It is applied to stones, pieces of brick, gravel, shells, etc., to which young oysters can attach themselves.

broken into comparatively small pieces before they are distributed on the grounds, to prevent the crowding of large numbers of spat on the same shell, as is now the rule. The shells could be broken at small cost, and the greater area of ground a certain quantity would cover would seem to warrant a slight additional expense.

26. *The Poquonock method.*—In the preceding discussions mention has been made of nearly all the methods resorted to in Connecticut to catch oyster spat, excepting the "brush" or "Poqnonock" method. The latter was discovered by accident, about 1868, cn the Poquonock River, a small stream in the town of Groton. A farmer, after trimming his orchard and throwing the branches of the trees into the river, was much surprised, in the succeeding autumn, to find the brush covered with oysters. This suggested the employment of the method to others, who used any cheap brush that was convenient. The material was usually placed in the water during May or June, and the spat secured in this manner was commonly taken off and marketed the following winter, or at least before the second winter. The chief reason for this was that the brush was generally put down in comparatively shallow water, about 2½ fathoms at low tide, and if the young oysters were allowed to remain on it for 2 years they would fall off by their own weight. They were also exposed to the danger of being "winterkilled" during cold weather, because of being so near the surface. They were generally large enough to market in 18 months or so, say about the beginning of the second winter.

The Poquonock method has been moderately successful, and perhaps is the best for the locality where it is employed. There are several reasons why it has not proved entirely successful; among which may be mentioned the collection of large quantities of eelgrass about the flats at the mouth of the stream, causing stagnation of the water and producing such conditions that the board of health of the town has caused the bushes to be pulled up and destroyed. However, while the bushes could be kept down, the young oysters have invariably grown rapidly, probably because the bottom of the river is very muddy.

As an illustration of this method we are informed, by one who has had large experience in the business, that on one occasion the spat obtained on a single bush produced 12 bushels of oysters. This, however, is seldom equaled. The Connecticut Bureau of Labor Statistics state that "one bush bore 25 bushels, but the average yield is about 5" (p. 112). This statement is thought to be rather large by those familiar with the subject. The consensus of statement is that this manner of collecting a "set" of oysters is less profitable than generally represented, but that greater success would result if the system could be tried in a locality where the water is less sluggish and where there would be no official interference.

27. *Suggestions.*—Mr. Stevenson suggests another method for collecting oyster spat, which seems worthy of trial, but has not yet been experimented with in Connecticut, so far as he knows: Strands of old rope, old netting or other flexible material could be suspended in the water on a horizontal line, similar to the ground line of a trawl, at the season when oysters are spawning. This might be a good arrangement and probably the material could be improved by coating it with rubber or some other material to which the young oysters would readily and easily attach themselves. One advantage would be that the young oysters could readily be transported wherever it was desirable to convey them; they could be easily separated and planted, while the collectors could be used in succeeding years.

28. *Contingencies of the business, etc.*—The greatest care and good judgment in preparing oyster grounds may fail to secure the chief object aimed at: the obtainment of a good "set." If the shells spread over the beds are permitted to lie on the ground they become covered with silt or slime, which renders them unsuitable for obtaining a "set" the following year. Nevertheless, some oystermen permit the shells to remain on the bottom and simply stir them up with a dredge the next summer, a short time before the spawning period of the oyster. The best method is to dredge the shells during "slack time" when the steamers are not needed for other purposes. The shells are landed and left on shore until the proper time to again spread them on the grounds. This method is comparatively new and is increasing in favor; in 1887 only 39,000 bushels were thus taken up in the whole State; in 1888 the number increased to 157,000 bushels; and the quantity in 1889 was 334,500 bushels. It is only just to say that a considerable percentage of this increase was due to the decrease in the quantity of spat secured. The value of the shells covers the cost of taking them up, so that there is no actual financial loss in the transaction, while there is an important advantage in having a "clean bed" for the spawning season.

29. *Care required.*—Constant care and vigilance are required to insure complete success in oyster planting, even when conditions are fairly favorable. In the first place the young oysters are exposed to the danger of being "winterkilled," even if a good "set" is obtained. If this peril is escaped, there is always danger of destruction by starfish, drills, or other enemies.

Many of the largest cultivators remove the young oysters into deeper water in the spring, where the conditions are better for growth, the crop less liable to injury or destruction by storms, and less exposed to other harmful agencies. When two years old the oysters are large enough for "seed," and quantities are usually sold every year to planters of Rhode Island, Long Island, and to some in Connecticut who have not all they need.

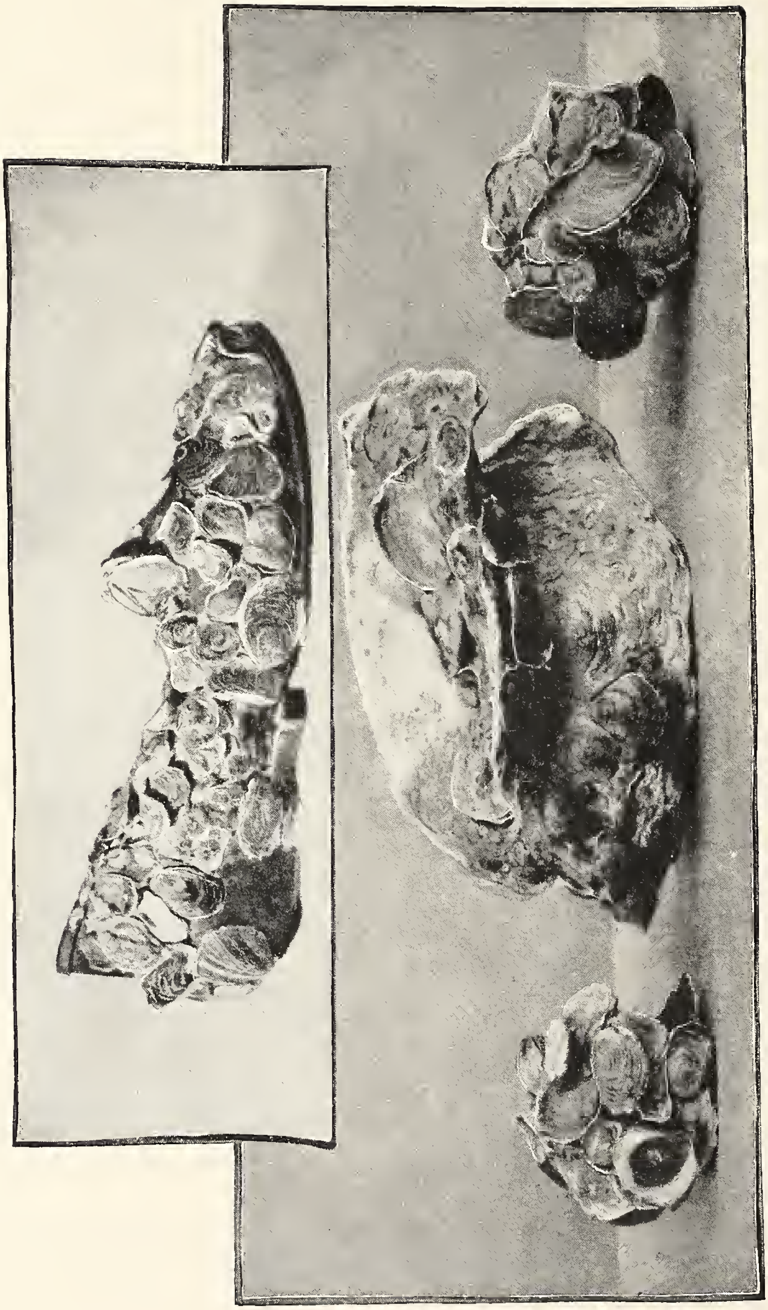
30. *Classification of oyster-planters.*—Those engaged in the cultivation of oysters in Connecticut may be roughly classified under three general heads. Most of them give greatest attention to one branch of the industry, engaging in the others to a less extent; while many do not divide their interests, considering it most profitable to limit their operations to one specialty. The classes may be designated as follows: Growers of oysters for opening; cultivators of stock for exportation to Europe; and seed-producers.

Those embraced in the first class are mostly located at New Haven. Of 863,890 bushels of oysters obtained by the cultivators of that city in 1889, 632,990 bushels were opened, 26,050 bushels sold in the shell for market purposes, and the remaining 204,850 bushels sold as seed to the planters of Rhode Island and Long Island. Besides the 632,990 bushels of oysters of their own production opened, the New Haven operators purchased 117,900 bushels, of which 80,500 bushels were raised in Connecticut and 37,400 bushels brought from Virginia.

Those who devote themselves chiefly to producing stock for exportation are mostly located west of Stratford, although during some seasons many oysters are taken east of that town for European markets.

Many of the oyster-planters give exclusive attention to raising "seed," which they sell to other cultivators, mostly out of the State. This business is increasing. The seed grounds are distributed all along the coast, the greater number being off

PLATE CLXIII.



YOUNG OYSTERS (AGE THREE TO SIX MONTHS) SET ON OYSTER SHELLS AND A RUBBER SHOE—TAKEN IN DREDGING FOR OYSTERS.

[From the Fifth Annual Report of the Connecticut Bureau of Labor Statistics.]

New Haven and Norwalk. The quantities and values of seed oysters produced in the State during the past three years were: 299,180 bushels in 1887, worth $155,000; 302,290 bushels in 1888, valued at $166,478; 446,249 bushels in 1889, worth $244,866.

31. *Growth of oysters, trade, etc.*—Local conditions have much to do with the growth or development of the oyster, and in a large measure influence the planters in the choice of the special branch of work in which they engage. The perception of the oystermen has been sharpened by keen competition; their judgment has been ripened by experience, and, with the active and enterprising spirit characteristic of them, they adopt such methods of work and trade as give the most profitable returns.

It has been mentioned that large quantities of seed oysters are sold to parties on Long Island, and it may seem somewhat remarkable that the latter can purchase seed from Connecticut and still successfully compete with the planters of that State. The reason is this: Oysters grow much more rapidly in the waters off the south side of Long Island than off the Connecticut shore. Stevenson says it is claimed that 2-year-old seed planted in the spring at Jamaica Bay (on the south side of Long Island) attain a marketable size by fall of the same year, while it would require at least two years to reach the same size in Connecticut waters. Indeed, there is said to be considerable difference in this respect between the eastern and western part of the State. The oysters near New Haven and eastward mature earlier than farther west. At Norwalk about 1,500 3-year-old oysters fill a barrel of ordinary size; from 1,200 to 1,400 of 4-year-old; 1,000 to 1,200 5-year-old; 800 to 1,000 6-year-old, and 650 to 825 7-year-old. There is considerable variation due to character of bottom, etc., but the above figures represent the average and ordinary differences in oysters of the same season.

The largest dealers, especially at New Haven, permit the oysters to remain on the grounds until of sufficient size to be placed on the market, which is about four years from the time of spawning. The age of marketable oysters varies, however, with the nature of the ground, the weather, and the locality.

After oysters attain a marketable size it is only necessary to dredge them and carry them to the shipping-point, or to the shucking and packing establishments. At New Haven or vicinity they mostly go to the oyster houses, where they are opened and packed in receptacles of various sorts and sizes for distribution over the country. At Bridgeport and Norwalk they may be assorted for sale to the exporters, or for exportation by the planter himself; or perhaps they are taken directly to New York for sale.

The Connecticut oystermen have four grades of oysters to which specific trade names are applied. Those 2 to 3 years old are "cullentines"; "culls" are commonly 3 years old or more; "boxes" range from 4 to 6 years old, and "extras" from 5 years upwards. The first two grades are generally opened and shipped without the shell; they are chiefly used for stews. The higher grades are mostly marketed in the shell, and from these come the choice stock for export to Europe. In 1889 the price of "culls" was about $3.50 per thousand, while "boxes" sold for $7 per thousand.

It will be readily understood that there must necessarily be much variation in the manner of handling the products, which it is not practicable to fully describe within the limits of these notes.

32. *Planting southern oysters.*—One important branch of oyster cultivation has not hitherto been described. This is the planting of southern oysters in Connecticut waters. This business is prosecuted only from New Haven Harbor, by the market-men at Fair Haven, which is that part of New Haven situated on the Quinepiac

River. The oysters are brought in the spring from the Lower Chesapeake and tributaries by sailing vessels, the freightage, etc., being about 10 cents per bushel. The cost, delivered in Connecticut, has been as follows: In 1887, 42 cents per bushel; in 1888, 45 cents, and in 1889 about 47 cents. The cost has been constantly advancing for several years, owing to increased scarcity.

After being taken to Connecticut they are bedded on grounds in New Haven Harbor, chiefly on the western side, on a long sandy bar, known locally as "The Beach." For this purpose an acre may have placed upon it as much as 2,000 bushels. The ground used is mainly the property of the owners of the oysters, but frequently it is hired for the season for bedding southern oysters, at a rental varying from 2 to 12 cents per bushel, according to location, the average being nearer the former than the latter price. The planters combine for mutual protection, employing watchmen, etc., to look after the beds.

These oysters are not taken up until winter, when they have increased greatly in size and attained much of the fine flavor characteristic of Connecticut oysters, for which they may be sold, or they are disposed of under their own name, according to the nature of the demand.

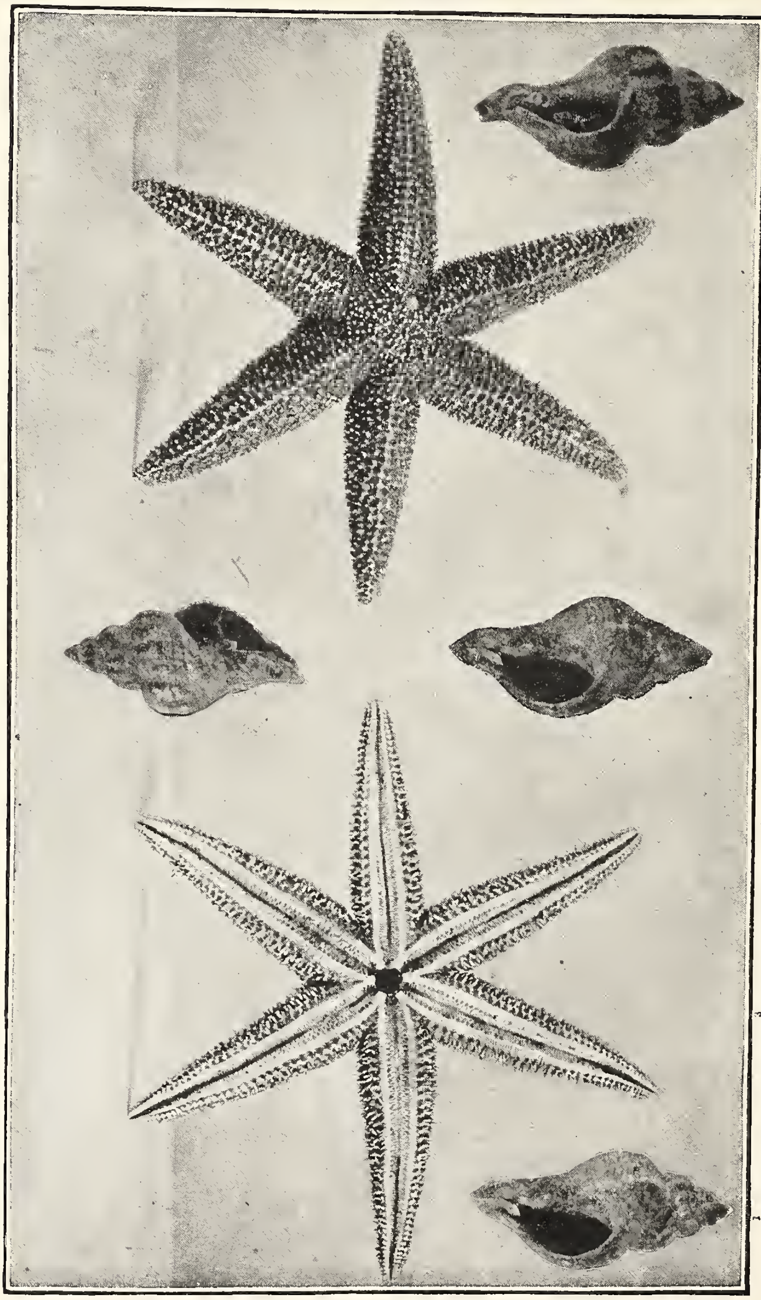
The following table shows the number of bushels planted during the past three years, their cost, the quantity taken up, and price received after opening:

Year.	Bushels planted.	Cost.	Bushels taken up.	Amount received.
1887	87,440	$36,101	110,900	$83,950
1888	95,325	41,585	124,100	93,450
1889	115,062	53,716	142,700	111,225

It will be observed that the oysters increased nearly one-third in bulk during the time they were bedded. The ratio of increase has slightly diminished recently, on account of the great destructiveness of the drills in New Haven Harbor.

Many oysters are still brought from the Chesapeake to be opened immediately upon their arrival. This trade began about 1835; it reached its maximum between 1855 and 1860, when probably between 500,000 and 750,000 bushels were annually transported. When native oysters began to be easily raised the use of southern oysters decreased; but, owing to the recent slight check in the productiveness of the Connecticut beds, it has increased somewhat during the past three years. In 1887 the number of southern oysters purchased to be opened at once was 32,500 bushels, costing $17,900; in 1888 it was 37,300 bushels, costing $19,194; and in 1889 it was 37,400 bushels, costing $21,682.

33. *Export trade.*—The exportation of American oysters to Europe depends chiefly on the product of the Connecticut grounds. As a rule, few oysters are taken from east of Milford for this purpose, though occasionally many are sent to Europe from New Haven. The stock intended for foreign markets consists of oysters carefully culled, after which they are packed for shipment in flour barrels holding about 3 bushels each. They are pressed down as tightly as possible into the barrels so that they will not rattle about, and also to prevent them from opening their shells; as long as the shells remain closed the liquid is retained, thus keeping the oysters alive much longer than would otherwise be practicable.



1. DRILLS (ONE AND ONE-QUARTER SIZE). 2 AND 3. VIEW OF UPPER SIDE AND UNDER SIDE OF STARFISH; SIX ARMS.

[From the Fifth Annual Report of the Connecticut Bureau of Labor Statistics.]

The quantity of oysters annually shipped to Europe from Connecticut amounts to about three-fourths of the entire transatlantic export from America of this mollusk. The shipping season extends from November to May. The business is conducted on steamships plying between New York City and European ports. About nineteen twentieths of them go directly to Liverpool. The following statement shows the total exportation of oysters from New York to European ports from 1878-79 to 1888-89:

Season.	Barrels.	Season.	Barrels.
1878-79	50,063	1884-85	98,802
1879-80	67,116	1885-86	98,997
1880-81	70,768	1886-87	100,906
1881-82	65,012	1887-88	99,123
1882-83	64,437	1888-89	103,109
1883-84	71,021		

There is a small trade with Canada. The oysters sent there are opened and shipped in tubs. Consignments leaving New Haven one day generally reach Montreal the next day.

34. *California trade.*—Comparatively few Connecticut oysters are shipped to California; oysters intended for that market are sent mostly from Newark Bay and localities farther south.

35. *Disposition of shells.*—A small business is carried on in New Haven in burning lime from oyster shells. About 80,000 bushels of shells are annually used for this purpose, of which 20,000 bushels are burned by the New Haven Gas Company. The average price is said to be $66 a carload of 600 bushels.* Thus the total value of this secondary product was $8,800.

36. *Methods of fishing.*—The two methods of fishing in vogue in Connecticut are tonging and dredging; it is not deemed necessary to speak of these processes in detail, as many elaborate descriptions have been published.

It may be mentioned that tonging is one of the oldest methods employed in America. Tonging from open boats is still prosecuted in Connecticut, particularly on the public beds, where the use of apparatus is restricted by law.

Dredging is the most common and important method; it is carried on very extensively on private grounds, and is the only system adapted to the cultivation of deep-water areas. Much improvement in this method has resulted from the introduction of screw steamers, which can tow four dredges and operate them by steam-power, whereas the sailing vessels can manage only two at most, and these must be slowly and laboriously operated by hand.

On a sailing dredger the dredge is usually hove up by a small hand-driven winch, upon which the tow rope is wound. The oysters are dumped on deck for culling, or in exceptionally cold weather they are thrown into the hold to prevent freezing.

On a steamer the process is quite different. When dredging, a section of the side of the deck house is removed, so that the oysters may be thrown on the main deck. As fast as the dredges are lifted they are swung in over the rail, their contents quickly emptied, and they are lowered again to the bottom for another load. This goes on continuously until the day's fishing is over. It naturally follows that much material is dredged that has to be culled out from the more valuable part of the catch; perhaps

* Report of Bureau of Labor Statistics, p. 134.

a portion is thrown over on the ground, for its improvement, but injurious material, such as starfish, drills, or other "rubbish," is carefully taken away and deposited where it can do no harm.

To wash the oysters, which is often done on the ground, the dredge is brought near the surface and before being taken on board it is raised and lowered several times, thus washing out the mud, sand, etc. Years ago there was much difficulty in doing this, since a positive clutch was used on the drum upon which is wound the dredge chain, and the latter could not easily be released; now this trouble is obviated by the use of a friction clutch.

There appears to be considerable variation in the capacity of dredges. Capt. Peter Decker says the dredges he uses on his new steamer "weigh 100 pounds, and a full bag will bring in 5 bushels."* Another authority states that the capacity of the average steamer's dredges is 10 to 12 bushels. There are few dredges that will dump 30 bushels.†

Oysters raised by the Poquonock method are lifted, bushes and all, by derricks.‡

VII.—UNFAVORABLE CONDITIONS, ENEMIES, ETC.

37. *Injury by unfavorable weather.*—Among the agencies tending to check the prosperity of the oyster industry in Long Island Sound, adverse weather during the spawning season may undoubtedly be given precedence. Warm, sunny weather is necessary to the life and healthy growth of the oyster spat; and to obtain a "set" is essential to financial success. Sometimes, even after an excellent "set" has been obtained, the young oysters are "winterkilled"—destroyed by the low temperature of the water in exceptionally cold weather. In many cases, when not killed, they are left in such a weakened condition in the spring that they are easily destroyed by enemies. To prevent this the oysters are often moved, before the weather becomes too cold, and planted in deep water, where they will not be affected by sudden changes of temperature.

In autumn and winter heavy gales frequently blow through the Sound with great force, particularly from the eastward. At such times the sea is heavy, and sweeps over the shallow oyster beds with destructive force. It is common, after a heavy easterly gale, to find the beaches strewn with windrows of oysters; frequently the oysters are smothered on the grounds by an accumulation of sand and mud. When oysters are washed out upon the shores the only remedy is to take them up and replant them. If this can be done in time they will be saved. Oysters planted in deep water are not liable to disasters of this kind, since beds at a depth of 35 feet or thereabouts are not usually affected by storms.

A study of the oyster question leads to the conclusion that there is a remarkable coincidence between years of moderately warm, clear weather, and subsequent seasons of exceptional abundance of oysters.

38. *Injury by mud.*—Although the development of the oyster is advanced by its vicinity to muddy bottom, injury through the influence of mud is one of the dangers to which it is liable. If, for instance, the infant oyster encounters the slightest film

* Report of Connecticut Bureau of Labor Statistics, p. 126.

† *Ib.*, p. 127.

‡ *Ib.*, p. 112.

1 AND 2. TWO STARFISH DESTROYING AN OYSTER; TWO VIEWS. 3. STARFISH; FIVE ARMS.

[From the Fifth Annual Report of the Connecticut Bureau of Labor Statistics.]

of mud, its gills are filled and suffocation ensues. This happens even if the water is only slightly muddy. For this reason muddy grounds are not suitable for the bedding of small oysters or for the collection of spat. Large oysters are not so liable to injury, as they are generally able to get their "bills" or "nibs" above the mud in which they are imbedded. Indeed, oysters grow much more rapidly in the vicinity of muddy grounds if they are large enough to escape injury from their surroundings. Excellent results have been obtained with ground of this character by distributing gravel over it in the proportion of about 200 tons per acre, or enough to prevent the oysters from sinking into the mud.

39. *Stagnant water.*—Injury to oysters by stagnant water is comparatively rare. The only place where Mr. Stevenson found this had occurred was on the Poquonock River, in the town of Groton. There the current is checked by eelgrass, and during hot weather it sometimes becomes peculiarly offensive and causes the death of the oysters within the limits of the stagnant water.

40. *Freshets.*—The danger arising from freshets is the opposite of that incurred from stagnant water. In some cases, oyster beds located at or near the mouths of such streams as the Thames and Connecticut Rivers are damaged by an excess of fresh water and heavy currents during the spring freshets. Not only does the water at such times destroy the oyster directly, but it is claimed that it develops a vegetable growth resembling a fungus which covers some of the beds and smothers the bivalve. This result can not be prevented, except by removing the oysters as soon as possible after the beginning of the freshet, a process attended with great difficulty and sometimes impracticable.

41. *Destruction by starfish.*—Next to bad weather and the consequent dangers which beset the young oyster, the most destructive agency in Connecticut waters is the starfish (*Asterias forbesii*), known in different sections by the various names of "sea-stars," "five-fingers," "crossfish," "sun-stars," and "stars." It is believed this pest destroys more oysters than all other agencies combined, except bad weather.

The starfish does not occur in fresh water, nor is it found in brackish water in numbers sufficient to be harmful; therefore, the so-called inshore grounds, particularly in the estuaries of rivers, do not suffer seriously from its attacks. Indeed, it was not until about 1882, when the grounds in the deep waters of the Sound had been stocked with oysters, that its enormous abundance and destructive power were fully understood. Large areas had been prepared for oyster beds, but many of the cultivators had so much ground that they could not attend to it properly, and, through neglect, it became a favorite breeding-place for starfish. No contrivance had been made suitable to cope with this destructive animal. One oyster-planter estimated the damage on one of his beds at $90,000 in six months, though in the same time he expended $9,000 in catching "stars."

There is a wide variation in the damage sustained from starfish by different firms and in different seasons. One firm having a product of $100,000 annually, estimated its loss in 1889 at only a few hundred dollars. The previous year, however, its beds were suddenly infested with myriads of "stars," and it was estimated that $15,000 worth of oysters had been destroyed before the actual condition was known. Another firm, with a yield of about $175,000 in two years, 1888–89, lost only about $2,500 worth from attacks of starfish. The diminished loss is due to the fact that these firms keep their steamers almost constantly patrolling the oyster beds.

It is claimed that some planters suffer severe losses because they own beds near grounds covered with starfish. Although they may make strenuous efforts to keep their beds clean, their work is rendered almost useless by starfish from neighboring grounds. This is one reason why oyster-farmers consider it a disadvantage for the State to reserve natural beds for public use, since no one has sufficient interest in them to spend time and money in keeping them free from starfish and other pests.

Notwithstanding the annual expenditure of many thousands of dollars to keep the beds free from starfish, the estimated damage done by them in Connecticut waters amounted to $463,600 in 1887, to $631,500* in 1888, and to $412,250 in 1889.

During 1889 many steamers were kept at work a greater part of the time in the effort to clean the oyster beds from "stars." One firm took from its beds in a single year 7,000 bushels, or 2,500,000 starfish in round numbers. In some cases 75 bushels were taken in a single day. The total quantity of starfish taken from Connecticut beds in 1888 amounted to about 42,000 bushels, or nearly 15,000,000 individuals.

The starfish is destructive to oysters of all sizes. The fishermen and planters hold varying beliefs respecting the method of attack, which will not be discussed here. The reader is referred to scientific treatises on the subject published elsewhere.† In a subsequent paragraph reference is made to the means employed to clean the beds.

42. *Drills.*—The drill and "winkles" are very troublesome to the oyster-planter. There are three species of these—the drill (*Urosalpinx cinerea*) and two kinds of periwinkle (*Sycotypus canaliculatus* and *Fulgur carica*)—all known by the common name of "borers," a term derived from the manner in which they are supposed to effect an entrance into the shell of an oyster. The drill is particularly destructive to small oysters, but the periwinkles are larger and consequently able to prey upon full-grown stock. What may be termed the tongue of the drill is provided with several rows of teeth-like appendages with which it rasps an entrance into the shell, and then the defenseless oyster is eaten piece-meal. The drill usually bores through the side of an oyster. In some localities these "borers" are more harmful than starfish, since they are always on the ground and always destructive, while the "star" is migratory and leaves the beds a portion of the year. These pests are most prominent in New Haven Harbor and at Princess Bay, New York. They apparently increase in numbers and destructive power each year. At New Haven the estimated damage done by them in the past three years was $15,000 in 1887, $20,000 in 1888, and $25,000 in 1889.

It is fortunate that this destruction is not widespread, for it is more difficult to rid the oyster beds of drills than to clean off the starfish. The latter are taken up with the oysters, even without special dredging, and to this extent at least the grounds may be frequently cleaned; but the drill is so small that few are ever taken in an ordinary dredge. The best remedy is to clean the infested locality thoroughly by dredging it several times, using a small-meshed net on the dredge; both oysters and "borers" are taken; the former are replanted and the latter destroyed.

43. *Other harmful agencies.*—There are various other minor enemies or agencies injurious to the oyster, but these are mostly of small consequence.

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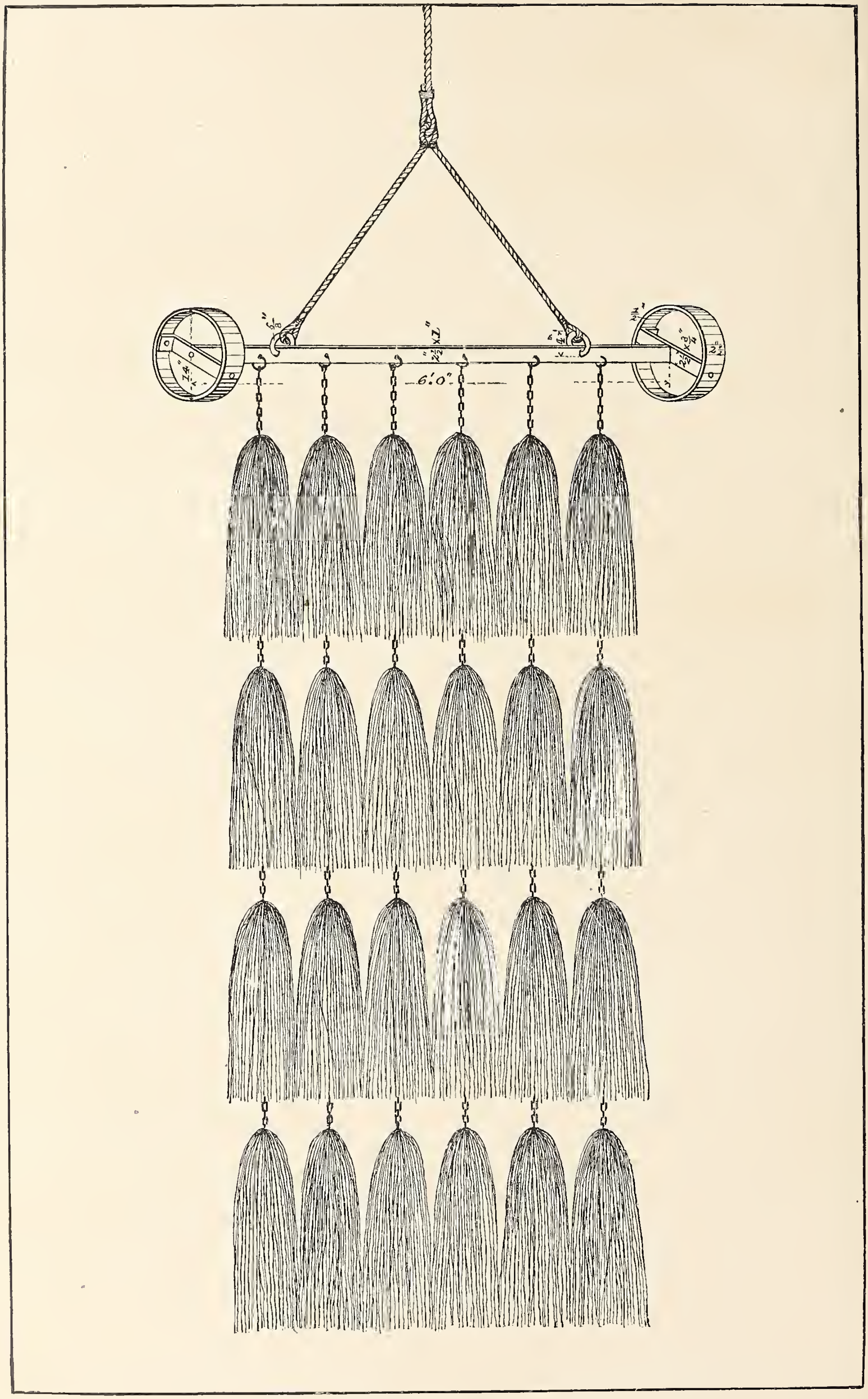
* The exceptional damage caused in 1888 is probably because they fed upon the large set of young oysters secured in 1887, which could be more easily destroyed than adults.

† See Ingersoll's Monograph, p. 228. Also Bulletin U. S. Fish Com., vol. v., 1885, p. 77. Also "A history of British starfishes," by Edward Forbes, p. 87.



TANGLES RIGGED FOR USE.

[From Report of the U. S. Fish Commission for 1883.]

It is estimated that 25 or 30 adult oysters produce eggs enough each season to equal the annual product of Connecticut waters, if all reached maturity. This exceptional fertility is nature's provision against the almost equal mortality in that critical period when the eggs or young are floating and when countless millions are destroyed by many agencies. It is believed that crabs and several species of fish consume large quantities of young when in the spat stage. All this affects the prosperity of the planter, but he feels most severely the loss of oysters after they reach a marketable size as "seed," "plants," etc. Much of this loss is unpreventable; but if some plan could be successfully adopted to protect the spat for at least a few weeks in its earlier stages, much might be gained. Some method like that suggested by Prof. John A. Ryder, embryologist of the U. S. Fish Commission (see Bull. U. S. Fish Com., vol. III, 1883, p. 281–294), might be found advantageous to oyster-planters. There are many ponds along the Connecticut coast suitable for experimenting with this method, and many others could readily be constructed at small expense.

In an appended table the estimated losses by starfish and other injurious agencies are given.

44. *Suggestions for removing starfish from oyster grounds.*—Much labor and inventive skill have been employed to accomplish this object, but with only partial success so far. The first plan was to dredge both oysters and starfish together, replant the former and destroy the latter. This method was too laborious, and much effort was put forth to discover some way of taking starfish without disturbing the oysters. Among the devices produced was a dredge, consisting, in general, of a pair of runners, to which was attached a net bag raised by framework a few inches above the runners. A valuable improvement to this consists of a line fastened between and connecting the two runners, and to it is attached numerous drags. These drags cause the starfish to rise from the oysters, so that the former are caught in the bag and secured without disturbing the mollusks.

In the investigations of the U. S. Fish Commission the ordinary tangles (made of hemp rope) have been found very effective in bringing up starfish and similar animals from the bottom of the sea, even in much greater depths than occur over the oyster beds in Long Island Sound. Several forms of tangles have been used. One consists of a triangular bar, shaped something like a harrow, with numerous bunches of rope yarn, like deck swabs, fastened to it. This would probably not be suitable for work on an oyster bed, because the iron frame would injure the oysters. Another form (see illustration, plate CLXVI) used by the Fish Commission would doubtless be very serviceable; this consists simply of an iron bar, with a fixed wheel at each end, and several series of tangles attached to the bar, at proper distances. Two or perhaps more of these could be used from a steamer at the same time, and it is believed they would be very effective in cleaning the ground. I would, however, suggest that revolving instead of fixed wheels be used. This style of apparatus has been thus described in a "Report on the construction and outfit of the U. S. Fish Commission steamer *Albatross*," published in the Report of the U. S. Fish Commission for 1883, p. 91:

This form of tangle bar * * * consists of an iron bar supported at each end by a fixed wheel or iron hoop. Six chains about 12 feet in length are attached to the bar at intervals of 1 foot. To these chains are secured deck swabs, or bundles of rope yarns, at intervals of about 18 inches. It is very useful on rocky bottoms, where it will capture specimens when no other device could be made available.

DIMENSIONS.

Wheels: Diameter, 1 foot 2 inches; width, 2½ inches; thickness of iron, one-half inch; width of crossbars, 2½ inches; thickness of crossbars, three-fourths of an inch.

Chain bar: Length, 6 feet; width, 2½ inches; thickness, 1 inch; rings for drag rope, diameter, 4 inches; rings for drag rope, diameter of iron, five-eighths of an inch.

Tangle chains: Diameter of iron, three-eighths of an inch; length, 12 feet.

Tangles, hemp, length, 3 feet.

VIII.—FINANCIAL RESULTS.

45. *In general.*—The oyster industry of Connecticut has probably been the most successful fishery on the Atlantic coast of the United States during the past decade. Its development and prosperity have been remarkable, as will be apparent from a comparison of past and present statistics. In 1880 the total investments in vessels, boats, equipment, and shore property amounted to $361,200. The product was 336,450 bushels of oysters, worth $386,625 to the producer. In 1889 the total investments were classified as follows:

Vessels, boats, and equipments	$423,544
Buildings, docks, etc	311,970
Accessory shore property and cash capital	278,200
Oyster grounds	1,237,695
Oysters on beds	1,424,855
	*3,676,264

The census of 1880 took no account of the value of oyster beds or the available crop upon them. Omitting these items for 1889, it will be seen that the investments in vessels, boats, shore property, etc., reached a total of $1,013,714, an increase over 1880 of nearly 300 per cent. The yield of the fishery in 1889 amounted to 1,485,861 bushels of oysters, with a value of $1,055,807, an increase over the census year nearly equal to the difference in investments.

Notwithstanding this general prosperity there have been instances where individuals were unfortunate because they entered into the business without sufficient knowledge of it to insure success. But with few exceptions the oyster-planters have been very successful. Many who started in the business with almost nothing have gained thousands of dollars by their energy and enterprise.

46. *Investments, etc.*—The greater part of the money now invested in the fishery has been made by the persons engaged exclusively in it. Fifteen years ago it is said there were few persons engaged in this fishery who were possessed of $10,000. Now one would scarcely be classed as a successful cultivator the value of whose oyster property alone does not reach $20,000. One company has over $400,000 invested, including the estimated value of oysters on the beds; another nearly $300,000, and several about $200,000 each. There are fifteen firms each of which has oyster property amounting to more than $50,000. Of those having less than $50,000 invested eighteen have over $20,000, and seventeen more than $10,000 but less than $20,000. These amounts are exclusive of cash capital, of which large sums are frequently employed.

* The above tabulation simply gives the present valuation of the oyster properties—the amounts for which they could be sold at ordinary market prices—and does not necessarily represent the money put into the industry.

47. *Profit and loss.*—In 1881, when the Shellfish Commission was authorized and the present system inaugurated, and in the years immediately succeeding, nearly everyone engaged in oyster-raising was successful. At that time grounds could be obtained at a comparatively low price; the high values of to-day were not thought of; satisfactory "sets" were secured quite regularly, and starfish had not then caused such havoc on the oyster beds as in recent seasons. Large profits accrued from small investments. The claim has been made that one investment of $200 realized a profit in 3 years of 8,500 per cent., but this is believed to be slightly exaggerated. During the past few years, however, there has been a multiplication of unfavorable influences. Many complain of losing money, and there appear to be more exceptions to the general prosperity than usual. Still, the industry as a whole has been very prosperous.

The receipts in 1889 (including the public beds) were $1,055,807, and the expenditures $632,283, leaving a profit of $423,524, which is more than 11 per cent. annual return on the investment, including the oyster grounds and the oysters on them. Some of the more fortunate have made much more than this average; others have fallen below it. In one case a firm reported receipts in 1889 amounting to about $75,000; their expenses were about $25,000; the previous year its receipts were over $100,000, expenses $30,000; in 1887 receipts about $50,000, expenses $28,000.

In another case the following results were obtained from a bed having an area a trifle less than 100 acres: In 1887 30,000 bushels of oysters were taken from it, after which 33,000 bushels of oyster shells were strewn over it, at a cost, including labor, shells, etc., of $2,500. A set was secured that summer and the spat lived successfully through the succeeding winter. In 1888 nothing was done to the bed except to search it for starfish, the expenditure for this amounting to about $500. In 1889 $1,200 was expended in hunting starfish and in taking up 4,200 bushels of oysters, which sold for $3,190. In December, 1889, there were 70,000 bushels of oysters on the bed (accepting the most conservative estimate) which it was expected would be taken up the next year; these had a value on the bed of $52,000. Thus the total expenditure for 3 years—1887 to 1889, inclusive—including the annual tax of $40, amounted to $4,320, while the money received from sales ($3,190) added to the value of the crop on the bed made a total of $55,190. This leaves a net profit of $50,870. The bed on which these results were obtained is considered only fair, worth about $70 per acre. The success was due, first, to the procurement of a good set, and, second, to vigilance in protecting the crop from injury by starfish. Stevenson thinks it represents very fairly what may be expected of grounds off the Connecticut shore if a good set is obtained and the ravages of starfish prevented.

To illustrate the losses met with by some, it is stated that one cultivator put $25,000 into the business; in 1889 he had received only $2,000 from his investment and offered to sell his entire oyster property for $7,500.

IX.—STATISTICAL STATEMENTS.

The tabular statements on the following pages cover other phases of the industry and convey a complete idea of the extent and condition of the business in each coast town during the years 1887, 1888, and 1889.

48. *Table of persons employed.*

Towns.	Fishermen and others engaged in cultivating and harvesting the oysters.										Shoremen and others engaged in preparing the oysters for market.									
	Number.			Nationality in 1889.							1887.		1888.		1889.		Nationality in 1889.			
	1887.	1888.	1889.	United States.	Swede.	German.	Irish.	Portuguese.	Russian.	Others.	Male.	Female.	Male.	Female.	Male.	Female.	United States.	Swede.	German.	Irish.
Greenwich	43	49	49	49																
Stamford	21	20	20	20																
Noroton	24	23	22	19	1	2														
Norwalk	143	127	143	129	5	3	3	2	1		24		32		35		33	1	1	
Westport and Fairfield	10	10	10	10																
Bridgeport	48	49	51	42	2	1	4	2			20		44		18		11	2	2	3
Stratford	28	28	23	13	5	1	3	1			42		36		30		25	3	2	
Milford	16	18	22	22							14		31		20		20			
New Haven	209	204	211	179	11	4	11			6	209	347	203	344	203	345	432	8	5	103
Branford	12	14	12	12																
Guilford	3	3	3	3																
Madison	8	9	8	8																
Clinton	8	8	8	8																
Quiambog and Mumford's Cove	7	7	7	7																
New London	4	4	4	4																
Total	584	573	593	525	24	11	21	5	1	6	309	347	346	344	306	345	521	14	10	106

49. *Table showing capital invested and annual expenditures.*

Towns.	Steam vessels.								
	Number.			Net tonnage.			Value, including outfit.		
	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.
Greenwich	1	1	1	34.75	34.75	34.75	$7,250	$7,050	$6,850
Stamford	1	1	1	8.34	8.34	8.34	2,000	1,900	1,800
Noroton	2	2		55.50	55.50		10,400	9,800	
Norwalk	13	14	14	322.89	346.50	346.50	76,450	86,100	80,750
Westport and Fairfield	1	1	1	7.73	7.73	7.73	2,000	2,100	2,000
Bridgeport	7	6	6	264.14	253.89	284.92	38,700	33,500	37,800
Stratford	4	4	4	179.44	179.44	179.44	23,790	22,800	21,300
Milford	2	2	3	76.02	75.98	85.31	17,350	16,950	20,590
New Haven	22	23	23	713.70	770.51	770.47	147,350	152,600	147,250
New London	1	1	*1	14.62	14.62	14.62	2,500	2,400	2,400
Total	54	55	54	1,677.13	1,747.26	1,732.08	327,790	335,200	320,740

Towns.	Sail vessels.									Boats.					
	Number.			Net tonnage.			Value, including outfit.			Number.			Value, including outfit.		
	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.
Greenwich	16	19	20	144.50	179.24	188.90	$9,515	$9,820	$11,185	80	80	81	$5,675	$5,775	$5,780
Stamford	7	6	6	59.91	46.53	46.53	4,430	3,745	3,600	28	28	26	2,700	2,700	2,664
Noroton	5	4	3	40.45	35.10	22.11	3,195	2,500	1,530	35	35	35	3,100	3,100	3,120
Norwalk	14	12	12	156.56	130.85	130.79	10,570	8,560	8,335	210	210	208	18,800	18,800	18,820
Westport and Fairfield	1	1	1	15.70	15.70	15.70	800	750	660	4	3	3	275	230	230
Bridgeport	7	7	5	80.74	80.74	49.29	6,505	6,225	3,920	20	20	21	3,220	3,220	3,280
Stratford										12	12	12	2,930	2,930	2,930
Milford	1	1	1	11.76	11.76	11.76	550	500	500	4	4	5	1,840	1,840	1,920
New Haven	14	12	11	225.91	181.39	165.93	15,590	12,490	11,200	110	110	111	17,700	17,700	17,855
Branford	2	1		17.17	10.98		1,250	600		11	11	10	490	490	450
Guilford										15	15	15	1,315	1,325	1,325
Madison										10	10	10	2,700	2,700	2,700
Clinton										5	5	5	250	250	250
Quiambog and Mumford's Cove										7	7	7	250	250	250
Total	67	63	59	752.70	692.29	631.01	52,405	45,190	40,930	551	550	549	61,245	61,310	61,574

* This vessel is employed exclusively in taking oysters in Rhode Island waters.

49. *Table showing capital invested and annual expenditures*—Continued.

Towns.	Total capital invested in vessels and boats.			Value of wharves and buildings.	Value of grounds.	Value of oysters on grounds.	Cash capital.	Total capital invested.	Aggregate expense in cultivating the beds and preparing the oysters for market.		
	1887.	1888.	1889.	1889.	1889.	1889.	1889.	1889.	1887.	1888.	1889.
Greenwich	$22,440	$22,645	$23,815	$500	$65,500	$60,000	$3,500	$153,315	$11,550	$13,370	$12,275
Stamford	9,150	8,345	8,064	2,900	24,210	25,000	4,000	64,174	5,595	5,485	5,290
Noroton	16,695	15,400	4,650	2,500	16,000	18,000	4,000	45,150	9,850	8,850	4,835
Norwalk	105,820	113,460	107,905	52,600	237,120	385,000	40,000	822,625	62,010	62,200	63,360
Westport and Fairfield	3,075	3,080	2,890	250	6,500	8,400	2,100	20,140	1,585	2,375	1,640
Bridgeport	48,425	42,945	45,000	27,200	65,390	72,000	22,000	231,590	22,790	29,365	28,025
Stratford	26,720	25,730	24,230	11,500	159,800	79,000	15,000	289,530	37,395	30,790	27,310
Milford	19,740	19,290	23,010	6,000	26,000	150,000	13,000	218,010	14,250	27,900	21,585
New Haven	180,640	182,790	176,305	204,250	613,540	609,155	172,100	1,775,350	271,864	228,419	264,406
Branford	1,740	1,090	450	3,500	8,800	7,500	2,000	22,250	3,385	4,515	3,995
Guilford	1,315	1,325	1,325	....	3,000	2,500	....	6,825	375	365	305
Madison	2,700	2,700	2,700	500	3,500	1,200	....	7,900	455	475	415
Clinton	250	250	250	200	1,850	5,000	500	7,800	1,465	1,475	1,345
Westbrook	....	....	....	....	125	....	....	125	....	....	....
Thames River	....	....	....	....	2,500	....	....	2,500	....	....	....
Poquonock	....	....	....	....	800	....	....	800	....	....	....
Quiambog and Mumford's Cove	250	250	250	70	3,000	2,100	....	5,420	1,375	1,905	1,665
New London	2,500	2,400	2,400	....	....	....	....	2,400	....	....	....
Stonington	....	....	....	....	60	....	....	60	....	....	....
Total	441,440	441,700	423,241	311,970	1,237,695	1,424,855	278,200	3,675,964	443,944	417,489	436,451

50. *Quantities and values of material used and of seed planted in preparing oyster grounds.*

Material used at the towns named.	Bushels.			Value.		
	1887.	1888.	1889.	1887.	1888.	1889.
Shells.						
Greenwich	48,000	46,000	18,000	$3,600	$3,280	$1,220
Stamford	11,000	10,000	8,000	800	700	520
Noroton	15,000	25,000	3,000	780	1,300	140
Norwalk	268,240	372,330	283,000	19,970	28,305	19,825
Westport and Fairfield	8,500	18,000	20,000	425	900	1,000
Bridgeport	65,500	81,200	135,000	3,275	4,100	6,730
Stratford	140,000	270,000	118,000	5,930	7,918	4,300
Milford	*170,000	*180,000	*180,000	3,700	4,200	4,200
New Haven	1,298,580	1,269,300	1,148,125	64,124	66,484	56,675
Branford	6,000	8,000	1,200	420	560	77
Total	2,030,820	2,279,830	1,914,325	103,024	117,747	94,687
Northern seed.						
Greenwich	11,000	4,800	1,500	3,800	2,000	600
Stamford	4,900	5,000	1,800	1,700	2,000	750
Noroton	2,000	2,000	1,000	800	1,000	500
Norwalk	39,140	41,000	23,300	10,170	17,160	8,100
Westport and Fairfield	1,300	3,700	2,500	500	1,400	950
Bridgeport	8,500	5,800	10,500	2,835	1,860	5,400
Milford	....	5,000	2,000	....	1,500	600
New Haven	24,260	52,550	55,400	8,211	15,880	19.395
Branford	13,000	12,000	4,900	9,000	8,250	3,520
Guilford	900	900	200	540	550	130
Madison	2,550	1,240	850	800	380	260
Clinton	2,500	2,600	2,800	900	980	1,100
Quiambog and Mumford's Cove	1,700	4,200	3,250	1,110	2,665	1,957
Total	111,750	140,790	110,000	40,366	55,625	43,262
Southern seed.						
New Haven	87,440	95,325	115,062	36,101	41,585	53,716

*Including gravel planted.

51. *Estimated value of oysters destroyed by enemies and other agencies.*

Towns.	Value of oysters destroyed by starfish.			Value of oysters destroyed by other agencies, as drills, mud, ice, frost, etc.			Total value of oysters destroyed.		
	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.
Greenwich	$1,500	$2,000	$1,500	$800	$800	$500	$2,300	$2,800	$2,000
Stamford	4,000	4,000	5,000	1,000	1,000	1,000	5,000	5,000	6,000
Noroton	1,000	1,000	1,000	400	400	350	1,400	1,400	1,350
Norwalk	90,000	85,000	71,000	5,000	5,000	5,000	95,000	90,000	76,000
Bridgeport	125,000	129,000	47,250	3,500	4,000	3,500	128,500	133,000	50,750
Stratford	32,000	26,000	25,000	400	500	500	32,400	26,500	25,500
Milford	1,500	1,500	1,000				1,500	1,500	1,000
New Haven	208,600	383,000	259,000	28,100	35,050	41,600	236,700	418,050	300,600
Branford			1,500						1,500
Total	463,600	631,500	412,250	39,200	46,750	52,450	502,800	678,250	464,700

52.—*Table showing the quantities and values of oysters and shells taken from private and public grounds.*

Oysters and shells taken from private and public grounds at the towns named.	Bushels.			Value.		
	1887.	1888.	1889.	1887.	1888.	1889.
I. Private grounds:						
Seed oysters:						
Greenwich	9,000	9,100	5,500	$6,750	$6,750	$3,850
Stamford	4,500	4,100	4,000	1,900	1,900	1,910
Noroton	7,000	8,000	8,000	4,100	4,500	4,600
Norwalk	145,080	140,780	132,899	76,330	81,978	78,621
Westport and Fairfield			3,500			1,925
Bridgeport		2,000	2,000		1,100	1,300
Stratford	10,500	750	1,500	6,275	285	820
Milford	35,000	38,000	84,000	19,250	24,700	54,600
New Haven	88,100	99,560	204,850	40,395	45,265	97,240
Total	299,180	302,290	446,249	155,000	166,478	244,866
Southern plants:						
New Haven	110,900	124,100	142,700	83,950	93,450	111,225
Native oysters to open:						
Norwalk	3,000	3,000	3,000	3,000	3,000	3,000
Bridgeport	2,000	2,000	2,000	2,200	2,200	2,200
Stratford	74,000	33,500	10,500	61,500	31,500	9,500
Milford		30,000			26,000	
New Haven	503,600	495,140	490,290	376,710	362,750	342,680
Total	582,600	563,640	505,790	443,410	425,450	357,380
Native oysters in shell:						
Greenwich	20,000	20,500	17,000	16,000	16,400	13,600
Stamford	12,000	10,000	10,150	12,000	10,000	10,150
Noroton	13,000	10,000	10,000	13,000	10,000	10,000
Norwalk	102,340	119,117	127,442	86,339	114,560	127,746
Westport and Fairfield	600	1,200	2,800	1,100	2,000	3,500
Bridgeport	29,777	43,379	48,080	32,260	43,960	48,165
Stratford	30,587	22,034	37,740	25,859	18,421	34,980
Milford	32,000	51,000	23,800	32,000	41,000	20,370
New Haven	77,536	36,707	26,050	44,160	27,970	22,200
Branford	11,000	11,500	6,500	13,400	14,000	8,100
Guilford	1,400	560	600	1,500	670	720
Madison	1,250	980	1,100	1,450	1,050	1,200
Clinton	4,000	3,700	4,100	6,000	5,900	6,500
Quiambog and Mumford's Cove	1,700	4,250	1,910	4,100	9,880	3,800
Total	337,190	334,927	317,272	289,168	315,811	311,031
Shells:						
Stamford		5,000	4,000		250	200
Norwalk	6,000	20,000	30,000	320	1,200	1,500
Bridgeport	10,000	42,000	28,000	500	2,100	1,400
Stratford			90,000			3,850
New Haven	23,000	90,000	182,500	1,050	4,450	8,920
Total	39,000	157,000	334,500	1,870	8,000	15,870

52.—*Table showing the quantities and values of oysters and shells, etc.*—Continued.

Oysters and shells taken from private and public grounds at the towns named.	Bushels.			Value.		
	1887.	1888.	1889.	1887.	1888.	1889.
II. Public grounds:						
Greenwich	6, 200	6, 000	1, 200	$2, 170	$2, 350	$360
Stamford	2, 400	2, 000	1, 500	800	700	500
Noroton	2, 000	1, 900	1, 100	800	800	520
Norwalk	28, 000	21, 500	12, 500	8, 400	6, 260	5, 750
Westport and Fairfield	7, 000	7, 000	6, 000	2, 000	2, 000	2, 000
Bridgeport	115, 000	31, 000	3, 500	19, 800	12, 610	1, 700
Stratford	19, 000	8, 000	4, 500	3, 800	2, 500	2, 200
Milford	6, 000	10, 000	8, 000	2, 150	3, 400	2, 400
New Haven	35, 000	81, 000	24, 000	12, 500	18, 000	9, 875
Branford	850	900	1, 100	285	270	330
Madison	12, 500	7, 000	5, 500	4, 500	2, 850	2, 580
Clinton	3, 500	3, 500	3, 500	1, 800	1, 800	1, 800
Wostbrook	1, 800	1, 300	1, 000	1, 300	1, 000	650
Saybrook	750	1, 500	200	950	1, 900	275
Niantic	....	....	40	....	....	80
Thames River	2, 000	1, 850	120	1, 000	925	60
Poquonock	800	460	90	2, 000	1, 150	225
Total	242, 800	184, 910	73, 850	64, 255	58, 515	31, 305
III. Total from public and private grounds (not including shells):						
Greenwich	35, 200	35, 600	23, 700	24, 920	25, 500	17, 810
Stamford	18, 900	16, 100	15, 650	14, 700	12, 600	12, 560
Noroton	22, 000	19, 900	19, 100	17, 900	15, 300	15, 120
Norwalk	278, 420	284, 397	275, 841	174, 069	205, 798	215, 117
Westport and Fairfield	7, 600	8, 200	12, 300	3, 100	4, 000	7, 425
Bridgeport	146, 777	78, 379	55, 580	54, 260	59, 870	53, 365
Stratford	134, 087	64, 284	54, 240	97, 434	52, 706	47, 500
Milford	73, 000	129, 000	115, 800	53, 400	95, 100	77, 370
New Haven	815, 136	836, 507	887, 890	557, 715	547, 435	583, 220
Branford	11, 850	12, 400	7, 600	13, 685	14, 270	8, 430
Guilford	1, 400	560	600	1, 500	670	720
Madison	13, 750	7, 980	6, 600	5, 950	3, 900	3, 780
Clinton	7, 500	7, 200	7, 600	7, 800	7, 700	8, 300
Westbrook	1, 800	1, 300	1, 000	1, 300	1, 000	650
Saybrook	750	1, 500	200	950	1, 900	275
Niantic	....	....	40	....	....	80
Thames River	2, 000	1, 850	120	1, 000	925	60
Poquonock	800	460	90	2, 000	1, 150	225
Quiambog and Mumford's Cove	1, 700	4, 250	1, 910	4, 100	9, 860	3, 800
Total	1, 572, 670	1, 509, 867	1, 485, 861	1, 035, 783	1, 059, 704	1, 055, 807

NOTE.—The total figures inclnde the quantity and value of oyster-shells resulting from the stock opened before being sold; but the sholls taken up from the beds as such do not enter into the totals.

X.—OYSTER LEGISLATION OF CONNECTICUT.

The following digest of Connecticut laws enacted prior to 1881 for the control of the shellfish fisheries of the State is from "The Oyster Industry," by Ernest Ingersoll, pages 67 to 70. The legislation of 1881 is the most important enacted by the State, and for this reason it is given in full, as supplementary to the digest.

[Laws of State of Connecticut, Chapter IV, Part I, Article I.]

SECTION 1. Describes the particular territory within which the selectmen of East Haven may "designate" or grant ground for the planting and cultivation of oysters; describes within what other waters the oyster committee of the same town may designate; and gives to the selectmen of Orange all the powers of an oyster committee.

SEC. 2. Provides that any town except East Haven and Orange may appoint a committee of not more than five electors, which shall designate to applicants suitable places in the navigable waters of the town for planting or cultivating oysters, clams, or mussels.

SEC. 3. Any person desiring to plant or cultivate oysters, clams, or mussels may apply in writing for a suitable place, and such committee or selectmen may make such designation, not exceeding 2 acres in extent, after the applicant has proved that the ground has not previously been set off for this

purpose; that the ground is within town limits; and that fees due to the town for this designation have been deposited. Town clerks may grant the required certificates, and town treasurers receipt for payments of fees. Violations of this act by members of town committees are punishable. Having received his designation, the applicant must mark the boundaries of his ground by buoys or stakes, set at suitable distances and labeled with the name or initials of the owner; and until then he shall not be permitted to catch oysters upon the ground. Designations may be made to several in common.

SEC. 4. Every person who shall plant or cultivate oysters, clams, or mussels in any such place shall own them, and also all other oysters, clams, or mussels in such place, and have the exclusive right of taking up and disposing of them and of using such place for the purpose of planting or cultivating oysters, clams, or mussels therein, which shall be transferable by written assignment, but nothing herein contained shall affect the rights of any owner of lands in which there may be salt-water creeks or inlets, or which may be opposite or contiguous to such navigable waters; nor the existing by-laws of any city, town, or borough; nor authorize any committee or selectmen to designate, or any person to mark, stake out, or inclose any natural oyster bed (except in New Haven harbor and its tributaries, and for a distance not exceeding 2 miles from the mouth of said harbor), or infringe the free navigation of said waters, or interfere with the drawing of seines in any place established and customarily used for seine fishing.

SEC. 5. Any person procuring oyster ground "for the purpose of assigning rights which he may acquire for profit or speculation," shall be fined $50.

SEC. 6. Amended and replaced by subsequent legislation, adds to the powers of the New Haven committee the power to designate ground for oyster planting and cultivation in the waters of Long Island Sound, which lies between East Haven and a line parallel to its boundary and 500 yards to the westward; and the selectmen of Orange may designate between this tract and a line due south from Savin Rock, even though such ground "may have been natural oyster beds." And the committee's previous designations in this territory are hereby confirmed.

SEC. 7. Enjoins that all designations of oyster ground, when made, shall be exactly recorded in the office of the town clerk, together with all descriptions and assignments; "and all attested copies of such applications, designations, and assignments, with a certificate that they have been recorded, shall be conclusive evidence of the fact of such record, and prima facie evidence of the validity of such application, designation, and assignment."

SEC. 8. Any owner who has lost the evidences of title to oyster ground, after having filed them with the town clerk, may apply to the town committee, and if he satisfies them of his claim, he may receive from them a new title; but there are heavy penalties for fraud under this provision. In case of boundaries being lost, or when the committee authorized to stake out oyster grounds have described the boundaries incorrectly, the superior court, as a court of equity, may, upon petition, order such uncertain boundaries to be reëstablished, according to prescribed methods, except in cases where a map of the ground has been filed with the town clerk, in which case uncertain bounds are to be established by a surveyor appointed by a judge of the superior court.

SEC. 9. When there are more than thirty designations in any one town the selectmen shall procure a map of the district.

SEC. 10. An owner desiring to dam or lock an inlet or salt-water creek for the purpose of cultivating oysters therein, the selectmen shall visit the spot and report upon the propriety of the request at a meeting of the town; if the meeting approves, the owner may build a dam, etc., as indicated by the selectmen, and maintain it during the pleasure of the general assembly.

SEC. 11. When any natural oyster bed is set apart, contrary to law, the superior court in the same county has power to revoke the designation, if it deems it best; but must give the owner time to remove any oysters and improvements on the property.

SECS. 12 and 13. Conferred privileges upon Guilford which that town declined to ratify.

SEC. 14. No person, except the authorized committee or selectmen, shall stake out or inclose any oyster grounds in navigable waters, unless such persons shall own this ground under the provisions of this chapter; penalty, fine not to exceed $50.

SEC. 15. Any member of a committee who shall designate ground for oyster cultivation upon natural oyster beds, or in any other place where it is prohibited by law, shall forfeit from $25 to $200, excepting in Orange, New Haven, and East Haven.

SEC. 16. Any other person than the owner, who shall unlawfully remove any shells or shellfish from a place designated for oyster planting, shall be fined not exceeding $300, or imprisoned not more than one year; but if the offense be committed at night, heavier penalties are decreed.

SEC. 17. Forbids taking any oysters or oyster shells from the Thames River between March 1 and November 1.

SEC. 18. Every person who shall willfully injure any inclosure legally designated for oyster planting, remove any buoys or stakes, injure any oysters, remove any shells from such inclosure, or willfully deposit mud there, shall be subject to heavy penalties, after trial before a justice of the peace, with right of appeal to the superior court.

SEC. 19. Provides penalties for injury to dams or locks of any oyster pond.

SEC. 20. Prohibits taking "shells or shellfish" between sunset and sunrise, from any navigable waters of the State (except clams in Branford harbor from April to October), under fine of $50 to $100, or imprisonment, or both.

SEC. 21. Prohibits the taking of shellfish, or the use of spears for taking fish, within any area designated for oyster planting, within 2 miles of the shores of Branford or East Haven; penalty, fine of from $7 to $100, or imprisonment.

SEC. 22. Prohibits the use of dredges in New Haven Harbor west of a line from Farm River to Scotch Cap, and north of a line from Scotch Cap to Southwest Ledge, and then westerly to Hines's place in Orange; prohibits taking shellfish in Morris Creek, except on or adjacent to one's own land; and prohibits dredging *by steam* anywhere away from upon one's own ground, more than 2 days in the week, under heavy penalities, which may be imposed by a justice of the peace, subject to an appeal to the superior court. Dredging on one's own ground is allowed, however, in East Haven waters to the owners of ground southerly of a line drawn from The Chimneys, through Quixe's Ledge and Adam's Fall, until it intersects a line drawn from the old light-house to Savin Rock.

SEC. 23. All sheriffs and constables shall, and any other persons may, seize any boat or vessel illegally used in dredging, with its tackle, apparel, and furniture, wherever found, within 1 year thereafter; and, if condemned, the boat, etc., shall be sold after the prescribed form.

SEC. 24. When there shall be found in any waters of this State on board any boat or vessel, illegally used under the provisions of this chapter, any dredge or shells and shellfish, it shall be prima facie evidence that said boat or vessel was used contrary to the provisions of said chapter.

SEC. 25. No person shall gather shells or shellfish in any waters of this State for himself or his employer unless he and his employer are at that time, and have been for 6 months previous, actual inhabitants of the State.

SEC. 26. Refers to lobsters.

LAWS SINCE 1875.

Since the revision of the statutes in 1875, the following additional laws have been enacted:

MARCH 16, 1878.—When oysters have been planted on any ground legally designated, and doubt arises as to the jurisdiction of neighboring towns over it, prosecutions against the owner may be made in either of the three towns nearest.

MARCH 27, 1878.—No committee or selectmen of any town shall designate, and no person shall mark, stake out, or inclose for the cultivation of oysters, clams, or mussels, any natural clam bed.

MARCH 27, 1878.—No person shall take or carry away from Branford or Farm Rivers any oyster shells or seed oysters, for the purpose of planting them on private beds; or more than 2 bushels of oysters in a single day; or shall use tongs for taking oysters there between May 1 and October 1; under penalty of forfeiting $14 before a justice of the peace in Branford or East Haven, with a right of appeal to the superior court.

NAVIGATION LAWS.

There are two clauses in the State's navigation laws (chapter VIII) which concern oysters, as follows:

SEC. 19. Every person who shall deposit any substance, except oyster shells, in the harbors of New Haven, Bridgeport, and Stamford, shall be fined from $50 to $500, or imprisonment, or both.

SEC. 20. Gives the city court or a justice of the peace jurisdiction in such cases.

REMEDYING WEAK TITLES.

By a series of amendments and resolutions the legislature has "healed" many weak titles to oyster ground, by enacting that designations of ground for planting and cultivating oysters, clams, or mussels shall be valid and confirmed, including:

I. All granted informally under the provisions of chapter 3, section VIII, although the owners may have lost their evidences of title after having filed the same with the town clerk (July 17, 1875).

II. All in which the applicant may be a married woman or a minor (March 16, 1878).

III. All in which the application was made for the purpose of transferring the privileges; and all such transfers are confirmed (March 27, 1878).

IV. All designations for "planting," where "cultivation" is not mentioned.

V. All designations of ground described as containing not over 2 acres to each applicant, exclusive of muddy or rocky bottom, although the total quantity of ground embraced in the designation may be more than 2 acres to each applicant (March 27, 1878).

VI. All designations previous to March, 1879, by the town of East Haven, between its westerly boundary and a line drawn due south from the center of the mouth of East Haven River.

ESTABLISHMENT OF A STATE COMMISSION FOR LOCATING OYSTER GROUNDS.

Finally, some months subsequent to the compilation of the previous legal information, the legislature of 1881 passed an act, given herewith in full, which reconstructs the methods hitherto in vogue and reads as follows:

An Act Establishing a State Commission for the Designation of Oyster Grounds.

Be it enacted by the senate and house of representatives in general assembly convened, The State shall exercise exclusive jurisdiction and control over all shellfisheries which are located in that area of the State which is within that part of Long Island Sound and its tributaries bounded westerly and southerly by the State of New York, easterly by the State of Rhode Island, and northerly by a line, following the coasts of the State at high water, which shall cross all its bays, rivers, creeks, and inlets at such places nearest Long Island Sound as are within and between points on opposite shores, from one of which objects and what is done on the opposite shore can be reasonably discerned with the naked eye, or could be discovered but for intervening islands. And all shellfisheries not within said area shall be and remain within the jurisdiction and control of the towns in which they are located under the same laws and regulations and through the same selectmen and oyster committees as heretofore. If a difference shall arise between any town and the commissioners as hereinafter provided for, as to the boundary line between said town and the area so to be mapped, said town, by its selectmen, may bring its petition to the superior court for the county within which said town is situated, to determine said boundary line, and said court upon reasonable notice to the parties shall hear said petition and appoint a committee to ascertain the facts in such case and report the same to said court, and said court shall thereupon make such order as may be proper in the premises.

SEC. 2. The three fish commissioners of the State now in office, and their successors, shall also be and constitute a board of commissioners of shellfisheries, and be empowered to make or cause to be made a survey and map of all the grounds within the said area in Long Island Sound which have been or may be designated for the planting or cultivation of shellfish; shall ascertain the ownership thereof, and how much of the same is actually in use for said purposes; they shall also cause a survey of all the natural oyster beds in said area, and shall locate and delineate the same on said map, which survey and map when completed shall not cost a sum exceeding $2,500, and shall report to the next session of the legislature a plan for an equitable taxation of the property in said fisheries, and make an annual report of the state and condition of said fisheries to the legislature, and the said commissioners shall be empowered to appoint and employ a clerk of and for said board, and they shall each give a bond to the State with sufficient surety for the faithful performance of their duties, and for the payment to the State treasurer of all money that may come into their hands under this act in the sum of $2,000.

SEC. 3. The said commissioners shall also be empowered, in the name and in behalf of the State,

to grant by written instruments, for the purpose of planting and cultivating shellfish, perpetual franchises in such undesignated grounds within said area as are not and for ten years have not been natural clam or oyster beds, whenever application in writing is made to them through their clerk by any person or persons who have resided in the State not less than one year next preceding the date of said application. The said application and the said grant shall be in manner and form as shall be approved by the chief justice of the State, and all such grants may be assigned to any person or persons who are or have been residents of the State for not less than one year next preceding such assignment, by a written assignment, in manner and form approved by said chief justice; and the said commissioners shall keep books of record, and record all such grants and assignments therein, and the same shall also be recorded in the town clerk's office in the town bounded on Long Island Sound within the meridian boundary lines of which said grounds are located.

SEC. 4. When any such application is filed with the clerk of said commissioners, he shall note on the same the date of its reception and shall cause a written notice, stating the name and residence of the applicant, the date of filing the application, the location, area, and description of the ground applied for, to be posted in the office of the town clerk of the town bounded on the said Long Island Sound within the meridian boundary lines of which said grounds are located, where such notice shall remain posted for 20 days. Any person or persons objecting to the granting of the grounds applied for, as aforesaid, may file a written notice with the town clerk, stating the grounds of his or their objections, upon the payment to said town clerk of the sum of 25 cents, and at the end of said 20 days the said town clerk shall forward all such written objections to the clerk of said commission; and in case such objections are so filed and forwarded the said commissioners, or a majority, shall upon 10 days' notice in writing, mailed or personally delivered to all the parties in interest, hear and pass upon such objections at the town in which such grounds are located as aforesaid, and if such objections are not sustained, and the area of ground is not, in the opinion of the commissioners, of unreasonable extent, they may, for the actual costs of surveying and mapping of such grounds, and the further consideration of $1 per acre, paid to the said commissioners, to be by them paid over to the treasurer of the State, grant a perpetual franchise for the planting and cultivating shellfish in such ground, or in any part of the same, in the manner aforesaid; and where no such objections are made, such grants may be made for the considerations hereinbefore named. At all hearings authorized by this act the said commissioners may, by themselves or their clerks, subpœna witnesses and administer oaths as in courts of law.

SEC. 5. The said commissioners shall, previous to the delivery of any instrument conveying the right to plant or cultivate shellfish on any of said grounds, make or cause to be made a survey of the same, and shall locate and delineate the same, or cause it to be located and delineated upon the map aforesaid, and upon receipt of said instrument of conveyance the grantee shall at once cause the grounds therein conveyed to be plainly marked out by stakes, buoys, ranges, or monuments, which stakes and buoys shall be continued by the said grantee and his legal representatives, and the right to use and occupy said grounds for said purposes shall be and remain in said grantee and his legal representatives: *Provided*, That if the grantee or holder of said grounds does not actually use and occupy the same for the purposes named, in good faith, within 5 years after the time of receiving such grant, the said commissioners shall petition the superior court of the county having jurisdiction over the said grounds to appoint a committee to inquire and report to said court as to the use and occupancy of such grounds in good faith, and said court shall in such case appoint such committee, who, after 12 days' notice to petitioners and respondents, shall hear such petition and report the facts thereon to said court, and if it shall appear that said grounds are not used and occupied in good faith for the purpose of planting or cultivating shellfish the said court may order that said grounds revert to the State, and that all stakes and buoys marking the same be removed, the costs in said petition to be paid at the discretion of the court.

SEC. 6. When, after the occupancy and cultivation of any grounds designated as aforesaid by the grantee or his legal representatives, it shall appear to said commissioners that said grounds are not suited for the planting or cultivation of oysters, said grantee, upon receiving a certificate to that effect from said commissioners, may surrender the same, or any part thereof, not less than 100 acres, to the State, by an instrument of release of all his rights and title thereto, and shall, on delivery of such instrument to the said commissioners, receive their certificate of said release of said grounds, the location and number of acres described therein, which shall be filed with the State treasurer, who shall pay to the holder the sum of $1 for every acre of ground described in said release where said sum has been paid therefor to the State. And the said release shall be recorded by the said commissioners in their record books, and in the town clerk's office in the town adjacent to and within the meridian

boundary lines of which said grounds are located. For all purposes relating to judicial proceedings in criminal matters the jurisdiction of justices of the peace of the several towns bordering on Long Island Sound shall extend southerly by lines running due south by true meridian from the southern termini of the boundary lines between said towns to the boundary line between the States of Connecticut and New York.

SEC. 7. Said commissioners shall provide, in addition to the general map of said grounds, sectional maps, comprising all grounds located within the meridian boundary lines of the several towns on the shores of the State, which maps shall be lodged in the town clerk's office of the said respective towns, and said commissioners shall also provide and lodge with said town clerks blank applications for such grounds and record books for recording conveyances of the same, and all conveyances of such grounds and assignments, reversion, and releases of the same shall be recorded in the books of said commissioners, and in the town clerks' offices in the towns adjacent to and within the meridian boundary lines of which said grounds are located, in such books as are provided by said commissioners, subject to legal fees for such recording; and the cost of all such maps, blank books, surveys, and all other expenses necessary for carrying out the provisions of this act, shall be audited by the comptroller and paid for by the treasurer of the State; and the said commissioners shall each receive for their services $5 per day for the time they are actually employed, as provided for in this act; their accounts for such service to be audited by the comptroller and paid by the treasurer of the State.

SEC. 8. All designations and transfers of oyster, clam, or mussel grounds within the waters of Long Island Sound heretofore made (except designations made of natural oyster, clam, or mussel beds) are hereby validated and confirmed.

SEC. 9. All the provisions of the statutes of this State relating to the planting, cultivating, working, and protecting shellfisheries upon grounds heretofore designated under said laws, except as provided for in section 8 of this act and as are inconsistent with this act, are hereby continued and made applicable to such designations as may be made under the provisions of this act.

SEC. 10. When it shall be shown to the satisfaction of the said commissioners that any natural oyster or clam bed has been designated by them to any person or persons, the said commissioners shall petition the superior court of the county having jurisdiction over the said grounds to appoint a committee to inquire and report to the said court the facts as to such grounds, and said court shall in such case appoint such committee, who after 12 days' notice to the petitioners and respondents shall hear such petition, and report the facts thereon to said court; and if it shall appear that any natural oyster or clam bed, or any part thereof, have been so designated, the said court may order that said grounds may revert to the State, after a reasonable time for the claimant of the same to remove any shellfish he may have planted or cultivated thereon in good faith, and said court may further order that all stakes and buoys marking the same be removed, the costs in said petition to be taxed at the discretion of the court.

SEC. 11. Any commissioner who shall knowingly grant to any person or persons a franchise, as hereinbefore provided, in any natural oyster or clam bed, shall be subject to a fine of not less than $100 nor more than $500, and if such franchise is granted the grant shall be void, and all moneys paid thereon shall be forfeited to the State; and the said commissioners shall in no case grant to any person or persons a right to plant or cultivate shellfish which shall interfere with any established right of fishing, and if any such grant is made the same shall be void.

SEC. 12. The superior court of New Haven County on the application of the selectmen of the town of Orange, and the superior court of any county on the application of the oyster-ground committee of any town in said county, shall appoint a committee of three disinterested persons of the town within the boundaries of which any natural oyster, clam, or mussel beds exist, to ascertain, locate, and describe by proper boundaries, all the natural oyster, clam, or mussel beds within the boundaries of such town. Said committee so appointed shall first give 3 weeks' notice, by advertising in a newspaper published in or nearest to said town, of the time and place of their first meeting for such purpose; they shall hear parties who appear before them, and may take evidence from such other sources as they may, in their discretion, deem proper, and they shall make written designations by ranges, bounds, and areas of all the natural oyster, clam, and mussel beds within the boundaries of the town they are appointed for, and shall make a report of their doings to the superior court, and such report, when made to and accepted by said court, and recorded in the records thereof, shall be a final and conclusive determination of the extent, boundaries, and location of such natural beds at the date of such report. It shall be the duty of the clerk of the court to transmit to the town clerk of each of said towns a certified copy of said report so accepted and recorded, in relation to the beds of such town, which shall be recorded by said

town clerk in the book kept by him for the record of applications, designations, and conveyance of designated grounds. Such public notice of said application to the superior court, and of the time and place of the return of the same, shall be given by said selectmen or oyster-ground committee as any judge of the superior court may order. It shall be the duty of the selectmen of the town of Orange, and of the oyster committees of other towns, upon a written request so to do, signed by twenty electors of their respective towns, to make such application to the superior court within 30 days after receiving a copy of such written request, and said application shall be privileged, and shall be heard and disposed of at the term of said court to which such application is returned, in preference to other causes. All expenses properly incurred by such selectmen and oyster-ground committees in said applications, and the doings thereunder, and the fees of said committees so appointed by court, shall be taxed by the clerk of said court and paid by the State upon his order. Any designation of ground for the planting or cultivation of shellfish, within the areas so established by such report of said committee, shall be void.

SEC. 13. The selectmen of the town of Orange and the committees of other towns shall, at the expense of their respective towns, procure and cause to be lodged and kept in the office of the town clerk of each town, respectively, accurate maps showing the boundary lines of their said towns in the navigable waters of the State, and all designations of ground for the cultivation of shellfish heretofore made and that shall hereafter be made within such boundaries, and shall number said designations on said maps, and shall cause to be designated on said maps all natural oyster, clam, and mussel beds lying within their several towns, respectively, as the same shall be ascertained by said report of said committees so recorded in said towns, as hereinbefore provided.

SEC. 14. All acts and parts of acts inconsistent herewith are hereby repealed, but this act shall not affect any suit now pending.

Approved, April 14, 1881.

ANALYSIS OF ARTICLE.

GENERAL INDEX.

{ NOTE.—The following index contains general references to the entire volume; more detailed indexes to the papers in the above list will be found at the pages indicated. }